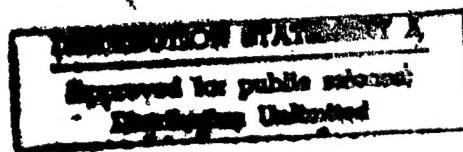


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# USSR Report

ENGINEERING AND EQUIPMENT

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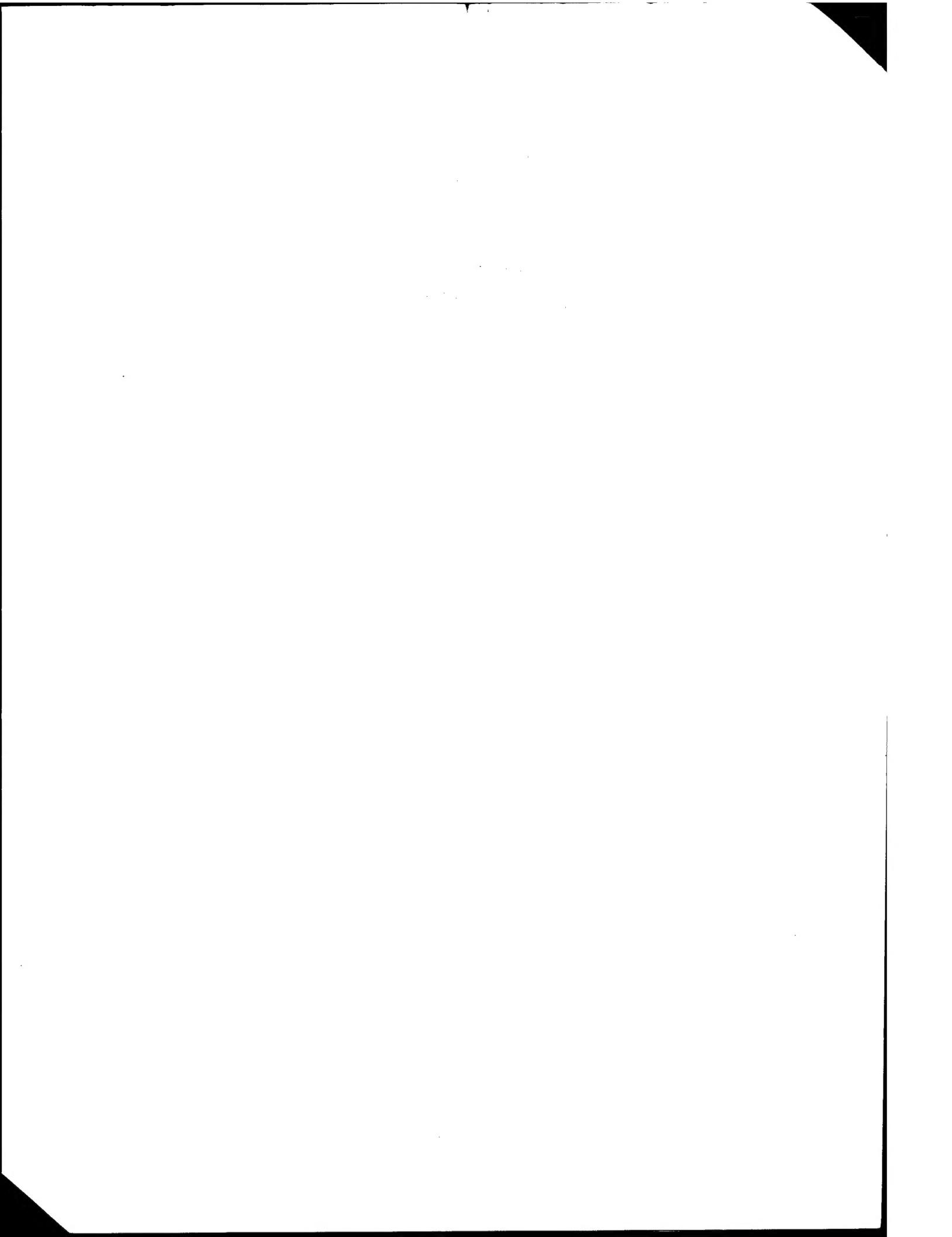
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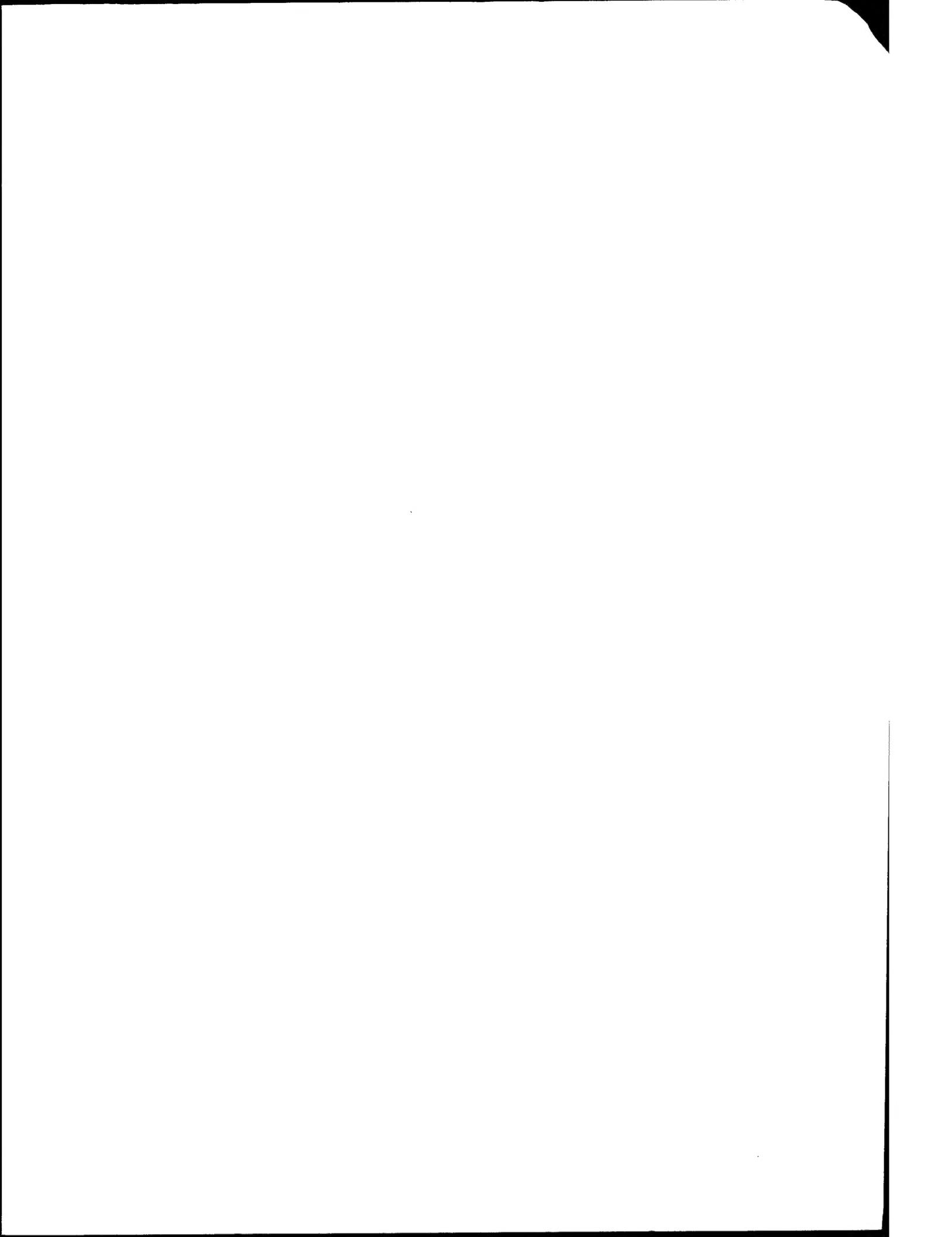
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**ENGINEERING AND EQUIPMENT**

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MARINE AND SHIPBUILDING

UDC 621.888.6:(621.431.74;621.436)

EXPERIENCE IN USE OF VIBRATION-ISOLATION MOUNTINGS FOR MARINE DIESEL ENGINES

Leningrad SUDOSTROYENIYE in Russian No 7, Jul 83 pp 19-21

IZAK, G. D. and TAYKHMAN, D. L.

[Abstract] The problem of vibration isolation and noise abatement on river boats is reviewed on the basis of experience in mounting diesel engines on shock absorbers. Data on the performance characteristics of four types of shock absorbers (APrS, AKSST, AKSSM, and slanting rubber-metal pads) have been correlated with the normal operating characteristics of seven diesel engines: 3D6N, 3D6, DGR 100/750 mounted on 10 slanting shock absorbers; 6ChNSP 18/22 mounted on 8 slanting shock absorbers; M401A mounted on 6 slanting shock absorbers; DGA25-9M mounted on 8 APrS shock absorbers; DGA50-9 mounted on 12 APrS shock absorbers. The mountings, all with safety features and the rubber-metal ones with special detents, have been designed not only to prevent their natural frequencies from coinciding with the frequencies of unbalance forces and moments over the entire range of engine speeds but also to ensure that the vibration amplitudes at engine speeds coinciding with those natural frequencies will remain within permissible limits. A cost analysis reveals that such mountings are economical means of reducing structural noise on diesel-driven boats. Nonelastic shock absorbers shift the frequencies of vibration caused by unbalance forces and moments below the range of engine speeds, while vibrations caused by imperfect coupling of engine shaft to propeller shaft and by hydrodynamic action will remain negligible. Figures 6, references 2 Russian.

[37-2415]

UDC 629.12.061:628.16.033

EXPERIENCE IN CONSTRUCTION OF EQUIPMENT FOR WATER CONDITIONING ON SHIPBOARD

Leningrad SUDOSTROYENIYE in Russian No 7, Jul 83 pp 16-18

VESELOV, Yu. S. and AKAT'YEVA, N. N.

[Abstract] The technology of water conditioning for the purpose of making it fit for drinking involves in the general (worst) case: deturbidization,

decolorization, deodorization, disinfection, conservation, and reduction of silver content to below 0.5 mg/l. A comprehensive review of scientific research and experimental engineering activities related to construction of equipment for water conditioning on shipboard reveals that developments in this area now in progress are aimed at providing maximum capability at the earliest data and at minimum cost, with standardization of equipment playing a major role in the achievement of this goal. The four major categories of shipboard water conditioning equipment targeted for standardization are: 1) mineralizers of water distillate; 2) disinfectors-conservers; 3) deturbidizers; 4) deodorizers. Mineralization measures include batching of salts, filtration, batching of natural (sea or ground) water, electrodialysis and electrophoresis. An automatic elution-type mineralizer consisting of main processing tank, reservoir, main and standby circulation pumps, and dispenser pump has already been developed in the Soviet Union in the early seventies. Disinfection measures include chemical methods such as chlorination, physical methods such as high-frequency or ultrasonic treatment, ozonization, ultraviolet irradiation, electrical treatment, as well as various combinations of chemical and physical treatment. For deturbidization, among the many available cartridge-type filters only those filled with a disperse charge preferably precoagulated are being considered tested for shipboard use. Most deodorizers operate on the basis of water filtration through a sorbent such as activated charcoal. Figures 6, references 2: 1 Russian, 1 Western.

[37-2415]

UDC 621.311.25:621.039.62-5

SELECTION OF ADJUSTMENT PARAMETERS FOR LEVEL AND PRESSURE REGULATORS  
OPERATING WITH SEPARATOR DRUMS IN POWER HOUSE WITH RBMK-1000 MW WATER-  
GRAPHITE CHANNEL REACTOR

Moscow TEPOENERGETIKA in Russian No 10, Oct 83 pp 10-14

DAVYDOV, N. I., doctor of technical sciences, FILAT'YEVA, R. I., engineer,  
VEZENITSYN, Yu. N., engineer, GULYAYEVA, T. A., engineer, and  
CHEREDNICHENKO, I. K., engineer, All-Union Institute of Heat Engineering  
and Chernobyl AES

[Abstract] A power house with an RBMK-1000 water-graphite channel reactor requires precise regulation of level and pressure in water-steam separator drums. While level regulation and pressure regulation can be analyzed separately, within the structure of an automatic control system they are interdependent and accordingly interfaced. First the level regulator is adjusted, taking into consideration the dynamic characteristics of the object with pressure stabilization as principal criterion, also the slopes of the characteristics of transducers. It is adjusted for necessary static dependence of water level on the load and necessary speed of regulation, taking into account both amplitude and period of level fluctuations. Correct adjustment requires a static level setting for adequate separation, a sufficiently wide sensitivity zone, adequate damping, and optimum regulator gain and integration time. In order to determine these parameters, it is necessary to calculate the relevant sensitivities and scale factors. On this basis one will also select the pulse signal of proper duration for regulator response. The pressure regulator, its dynamics being influenced by the level regulator, is adjusted next. Figures 4, references 3 Russian.

[30-2415]

EXAMPLE OF NEUTRON ENTRAINMENT BY FLOWING COOLANT SIGNIFICANTLY AFFECTING CRITICAL STATE OF REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 24 Jan 83) pp 184-186

KOSTRITSA, A. A.

[Abstract] It is demonstrated theoretically that entrainment of neutrons near the moderator inlet to or outlet from the reactor core has a strong stabilizing effect in a steady reactor with intense coolant flow and high xenon concentration but less than maximum xenon absorption. Calculations are based on the model of a conventional planar reactor with uniform fuel distribution over the core and with symmetric reflectors, in the 2-group approximation, where the moderator has been identified with the coolant. The reflectors are assumed to contain nothing except flowing coolant, the reactor core is assumed to contain only flowing coolant and stationary fuel with absorber. The age of neutrons is assumed to be the same in the core and in the reflectors. The reactor power is calculated for the case of zero neutron displacement  $\zeta = 0$  by the coolant stream as well as for the cases of neutron displacements  $\zeta$  equal to 10% and 20% of the length of their diffusion path in the moderator. The reactor power at  $\zeta = 0$  is found to decrease rapidly and to asymptotically approach its level at  $\zeta \neq 0$  either as the ratio of cross section for neutron absorption in the fuel to cross section of neutron absorption in moderator decreases or as the uniformly distributed component of the absorber increases. According to the results of these calculations, both the absorber and the entrainment of neutrons provide regulating action together within a narrow range of small controllable variations of the absorber near its danger level. Figures 2, references 4: 3 Russian, 1 Western.  
[35-2415]

AUTOMATIC SYSTEM FOR MONITORING TECHNOLOGICAL PROCESS OF EXTRACTION OF TRANSPLUTONIUM ELEMENTS

Moscow ATOMNAYA ENERGIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 8 Dec 82) pp 179-180

BIKINEYEV, V. A., GLUSHAK, N. S., PEVTSOV, V. V., FILIPPOV, A. N.,  
TSELISHCHEV, I. V. and SHIPILOV, V. I.

[Abstract] A simple automatic system has been developed for monitoring the technological extraction of transplutonium elements (Am, Cm). Based on a 15VSM-5 computer, this system includes 8 spectrometric and 32 counting immersion-type  $\alpha$ -radiation detectors. The detectors are of the semiconductor

type: the counting ones based on n-Si with surface barrier, the spectrometric ones based on p-Si with surface barrier or on p-Si(Li) with drift. In the counting mode the system operates with 2 pulse counters for 32 channels. In the spectrometric mode the system operates with a 512-channel pulse analyzer for 8 channels. Periodicity and cyclicity of each mode are set by a timer and a respective controlled commutator switch, their operation being programmed in the computer. The output signals of counting detectors are transmitted to two 24-bit counters through a preamplifier, an array of integral discriminators, and switches. The output signals from spectrometric detectors are transmitted to the 512x16-words direct-access computer memory through a preamplifier, an array of hermetic contactors, an amplifier, and an analog-to-digital converter. The analyzer operation is organized by the computer, taking into account the limited speed of the latter, through a CAMAC controller crate. Remote data display is available on the screen of an "Elektronika VL-100" industrial television receiver. The data display has been checked against results of laboratory analysis, and appropriate calibration factors have been stored in the computer memory. Figures 2, tables 3, references 7 Russian.

[35-2415]

UDC 621.039.519:621.039.562

#### METHODS OF MEASURING $^{10}\text{B}$ BURNUP IN ABSORBING REACTOR FUEL ELEMENTS

Moscow ATOMNAYA ENERGIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 24 Jan 83) pp 184-185

KOROLEVA, V. P. and OTSTAVNOV, P. S.

[Abstract] Because of its large cross section for absorption of thermal neutrons,  $^{10}\text{B}$  is used as principal material for control rods in reactors. This material burns up nonuniformly, however, which causes unsteadiness of rod performance and makes it particularly necessary to monitor the burnup level have been evaluated comparatively from the standpoint of optimum applicability: 1) recording transmitted or reflected neutrons; 2) measuring the ratio of  $^{10}\text{B}$  concentration to  $^{11}\text{B}$  concentration before and after irradiation with neutrons; 3) recording the products of  $^{10}\text{B}$  ( $n, \alpha$ ) $^{7}\text{Li}$  reaction ( $\alpha$ - particles and Li nuclei) during irradiation with neutrons; 4) measuring the amount of helium generated during irradiation with neutrons; 5) measuring the amount of lithium generated during irradiation; 6) activation analysis; 7) recording neutrons or  $\gamma$ -particles after irradiation with  $\alpha$ -particles; 8) recording momentary  $\gamma$ -quanta in excited  $^{7}\text{Li}$  nuclei generated during interaction of neutrons and  $^{10}\text{B}$ . Activation and analysis and recording prompt  $\gamma$ -quanta are the best methods from the standpoint of minimum interference by impurities, the latter method being the only nondestructive one. All other methods are either too inaccurate or not sufficiently reliable, the method of lithium determination being on the whole not quite feasible.

References 11: 8 Russian, 3 Western.

[35-2415]

DETERMINATION OF NUCLIDE CONTENT AND BURNUP LEVEL IN SPECIMENS OF VVER-440  
REACTOR FUEL

Moscow ATOMNAYA ENERGIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 13 Sep 82) pp 175-176

GABESKIRIYA, V. Ya., YEFREMOV, Yu. V., KALYGIN, V. V., MASLENNIKOVA, M. N.,  
MISHENEV, V. B., POPOV, Yu. S., PRIVALOVA, P. A., PROKOP'YEV, V. M. and  
CHETVERIKOV, A. P.

[Abstract] Two specimens of spent nuclear fuel in the fourth VVER-440 water-moderated water-cooled 440 MW power reactor of the Novovoronezh AES were examined for nuclide content and burnup level, these specimens having been cut from a fuel element with 3.5% initial  $^{235}\text{U}$  enrichment and located respectively 1375 and 1625 mm above the bottom of the core. The relative amounts of actinide isotopes ( $^{235}\text{U}$ ,  $^{236}\text{U}$ ,  $^{238}\text{U}$ ,  $^{239}\text{Pu}$ ,  $^{240}\text{Pu}$ ,  $^{242}\text{Pu}$ ,  $^{241}\text{Am}$ ,  $^{243}\text{Am}$ ,  $^{244}\text{Cm}$ ) and fission products ( $^{133}\text{Cs}$ ,  $^{134}\text{Cs}$ ,  $^{135}\text{Cs}$ ,  $^{137}\text{Cs}$ ,  $^{140}\text{Ce}$ ,  $^{142}\text{Ce}$ ,  $^{144}\text{Ce}$ ,  $^{142}\text{Nd}$ ,  $^{143}\text{Nd}$ ,  $^{144}\text{Nd}$ ,  $^{145}\text{Nd}$ ,  $^{146}\text{Nd}$ ,  $^{148}\text{Nd}$ ,  $^{150}\text{Nd}$ ) were determined with a mass-spectrometer by the method of isotope dilution and complex tracer. A better measurement accuracy was ensured by making each isotope determination in six parallel batches and using three different tracers, the latter containing always the optimum amounts of appropriate isotopes. The burnup level was determined by the method of heavy atoms and by the method of fission products. The results indicate a buildup of approximately 10 kg Pu with 6-16 g Am and 5 g Cm per metric ton of initial U. Tables 2, references 6: 5 Russian, 1 Western.

[35-2415]

EFFECT OF  $\alpha$ -PARTICLES CONTAINMENT ON CHARACTERISTICS OF AMBIPOLAR REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 8 Dec 82) pp 148-151

VASIL'YEV, N. N. and KUZNETSOV, M. G.

[Abstract] Completely steady operation of a reactor with ambipolar plasma containment in the catchers is feasible, this not being the case with other means of magnetic containment, but it depends on the removal of  $\alpha$ -particles accumulating here as the helium concentration becomes excessively high. The center catcher can be most efficiently purged of  $\alpha$ -particles by means of a transverse thermionic drift. Mechanisms of such a transport of helium ions are classical temperature and potential gradients with or without a reverse gradient of plasma concentration, neoclassical diffusion in a nonaxisymmetric magnetic field, and anomalous transport processes. The

dependence of the reactor performance on the containment level of  $\alpha$ -particles has been analyzed parametrically on the basis of a zero-dimensional model of plasma physics, the parameters being the capture coefficient for fast  $\alpha$ -particles and the transverse containment time in the center catcher. The six energy equations (for ions in center catcher, for electrons in center catcher, for electrons in locking catcher, for ion balance in locking catcher, for balance of thermal  $\alpha$ -particles) were solved for a reactor with heat barriers delivering 800 Mw of thermonuclear power under a neutron load of  $1 \text{ MW/m}^2$ , with a 40 m long center catcher, a 2.25 m plasma radius, and a maximum magnetic induction of 14 T in a lock. The results indicate that the power gain is not much higher than  $Q = 1$  with complete containment of fast  $\alpha$ -particles and will not exceed  $Q = 4$  even with use of heat barriers. Any containment of  $\alpha$ -particles thus detrimentally increases the plasma pressure. Partial containment being always inevitable, it is necessary to ensure a sufficiently intense radial diffusion of plasma with a characteristic diffusion time comparable with the longitudinal containment time. Figures 2, table 1, references 12: 2 Russian, 10 Western.

[35-2415]

UDC 621.039:620.193.01

#### SURFACE CONDITION OF STRUCTURAL MATERIALS IN MAIN SYSTEMS OF AES WITH RBMK-1000 REACTORS AFTER LONG PERIODS OF SERVICE

Moscow ATOMNAYA ENERGIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 21 Sep 82) pp 145-147

SEDOV, V. M., KRUTIKOV, P. G., NEMIROV, N. V., GRUSHANIN, A. I.,  
PAPURIN, N. M., YEGOROV, V. M. and YEPERIN, A. P.

[Abstract] A study was made for the purpose of determining the surface condition of structural materials in AES systems with RBMK-1000 MW water-graphite channel reactors after 60,000 h of operation, specifically carbon steels (St3, St20) and alloy steel (OKh18N10T) used for the condensate and feed water system. The main components of this system are closed water feed duct (St20 steel, water, 165°C), the deaerator guide vanes (OKh18N10T steel, water, 164°C and 7 MPa), upper deaerator housing (St3 steel, steam, 164°C and MPa), lower deaerator housing (St20 steel, water, 164°C), live-steam duct to second separator-superheater stage (St20 steel, steam, 280°C and 65 MPa), steam duct from high-pressure cylinder to first separator-superheater stage (OKh18N10T steel, steam, 211°C and 19 MPa), piping from separator-superheater (OKh18N10T steel, water, 136°C). The phase composition (FeO, Fe<sub>3</sub>O<sub>4</sub>,  $\alpha$ -Fe<sub>2</sub>O<sub>3</sub>) as well as the amount (mg/m<sup>2</sup>) of corrosion products and scale deposit on the inside surfaces were measured. For correlation, anodic potentiodynamic curves for these steels in a borate buffer solution (pH = 7.4 at 20±2°C) were recorded first with the surface after exposure to water and steam in service and then with the surface ground. The results indicate significant structural changes in pearlitic steel and a spontaneously stabilizing neutral oxidation by radiolytic oxygen. Figures 3, table 1, references 8 Russian.

[35-2415]

FUEL BURNUP LEVEL AND RESIDUAL ISOTOPE CONTENT IN VVER-440 REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 55, No 3, Sep 83  
(manuscript received 22 Nov 82) pp 141-145

STEPANOV, A. V., MAKAROVA, T. P., BIBICHEV, B. A., BELYAYEV, B. N.,  
FRIDKIN, A. M., LOVTSYUS, A. V., PREOBRAZHENSKAYA, L. D., LIPOVSKIY, A. A.,  
AKOPOV, G. A., KULAKOV, G. A., SIDORENKO, V. D., BULYANITSA, L. S.,  
NIKITINA, S. A., MALYSHEV, N. A. and RAZUVAYEVA, M. A.

[Abstract] For the purpose of improving theoretical calculations pertaining to the reactor fuel system, an experimental determination was made of its burnup characteristics in a VVER-440 water-moderated water-cooled 440 MW power reactor. Specimens cut from four fuel elements in a hexagonal array of 126 were tested, two with 3.3% and two with 3.6% initial enrichment. The burnup level was measured after respectively five and three operating runs with attendant neutron irradiation. The residual amounts of U, Pu, Am, Cm, Cs, Nd nuclides, referred to their initial content in the fuel, were measured each time. These measurements were made after the specimens had been dissolved in 8 mol./l HNO<sub>3</sub> at 90-95°C and then diluted in 2 mol./l HNO<sub>3</sub>. The mass fractions of these isotopes were determined in aliquot extracts, chemical extraction of U and Pu preceding that of Am and Cm. The results were correlated with the positions of given fuel elements in the array. Subsequent computer calculations were made according to the ROR program and the more precise UNIROSSOS program, both designed for describing the neutron spectra and computing the cross sections for actinoidal and fission nuclides in the Novovoronezh AES. Figures 4, table 1, references 11:  
9 Russian, 2 Western.

[35-2415]

SELECTION OF STRUCTURAL MATERIALS FOR HIGH-TEMPERATURE NUCLEAR ELECTRIC TECHNOLOGICAL PROCESSING PLANT WITH HELIUM COOLANT

Moscow ENERGOMASHINOSTROYENIYE in Russian No 6, Jun 83 pp 18-20

ANTIKAYN, P. A., doctor of technical sciences, FEDORTSOV-LUTIKOV, G. P.,  
candidate of technical sciences, and ZOT'YEV, Yu. A., candidate of technical sciences

[Abstract] The first high-temperature nuclear electrochemical processing plant now being built in the Soviet Union is the VRG-50 with a 50 MW reactor using spherical fuel elements and helium coolant. An important structural feature here is isolation of "hot" helium from powerhouse casings under pressure by a "double-wall" arrangement with "cold" helium contained between

casing and outer shell. While helium is an inert gas, it contains impurities which cause oxidation or carburization of surfaces and thus decrease the mechanical strength of materials and their stability. These impurities in the VGR-50 plant are (in vol.%)  $5 \cdot 10^{-6}$  CO<sub>2</sub>,  $0.25 \cdot 10^{-6}$  O<sub>2</sub>,  $50 \cdot 10^{-6}$  CO,  $2 \cdot 10^{-6}$  H<sub>2</sub>O,  $50 \cdot 10^{-6}$  H<sub>2</sub>,  $25 \cdot 10^{-6}$  N<sub>2</sub>,  $5 \cdot 10^{-6}$  CH<sub>4</sub> coming from ceramic materials in the reactor core, water and steam, and air. The main problems in designing the plant structure are to ensure adequate helium impermeability of welds and split joints, protection against self-welding of surfaces in contact, adequate wear resistance of rubbing pairs (in fuel circulation system), and adequate stability of mechanical properties of materials in a helium atmosphere at high temperatures. On the basis of accumulated and analyzed experience with helium-cooled reactors in the Soviet Union and abroad, the Central Scientific Research Institute of Heavy Machinery and the All-Union Scientific Research Institute of Atmoci Machinery have jointly developed recommendations for selection of structural materials for such processing plants. The common characteristics of these materials are high strength and stability during prolonged heating, high radiation resistance, high weldability of thick parts, low ductile-to-brittle transition point and high ductility. The elements in these materials have large cross sections for radioactive absorption and long half-life periods. Among these materials are 15Kh2NMFA steel for reactor and core containment structures, 22K steel for steam generator housing, 12Kh1MF and 08Kh18N12T steels for steam generator tubing, 20Kh1MF1BR steel for fasteners, 08Kh18N10T and KhN35VT (chromated+nitrified) steels for components of fuel circulation mechanism, 20Kh3MVF (nitrogenated) steel for gears, and sulfided molybdenum for bearing linings. Table 1, references 7 Russian.

[16-2415]

UDC: 621.039.515

#### SOME METHODS OF TESTING AND CONTROL OF NUCLEAR REACTOR NEUTRON FIELD

Kiev ELEKTRONNOYE MODELIROVANIYE in Russian No 3, May-Jun 83  
(manuscript received 19 May 81, after revision 27 Jul 82) pp 67-72

POTAPENKO, P. T.

[Abstract] A study is made of a harmonic reactor model, methods and equipment for monitoring and control to facilitate an increase in heat production reliability and safety of reactors. A structural diagram is presented of a diactimeter, an instrument for measurement of the azimuthal diactivity vector. The device allows practically instantaneous recording and compensation of diactivity, the prime cause of the dangerous power differences between the halves of the reactor core. Diactivity and dipolarity are the input and output signals for the first harmonic of the neutron field. The most important principle of control of reactors is that diactivity and dipolarity must be maintained at or near zero. The instruments described in this article for measurement of the first azimuthal harmonic by means of sensors both

inside and outside the reactor and regulation systems including a power regulator and two dipole regulators have been successfully tested on power reactors. Figures 3, references 7 Russian.

[25-6508]

UDC: [621.311.25:621.039]:628.542

COMBUSTION OF NUCLEAR POWERPLANT SOLID WASTES

Moscow ELEKTRICHESKIYE STANTSII in Russian No 8, Aug 83 pp 9-12

FEDORENKO, V. F., engineer and KHARLAMPOVICH, G. D., doctor of technical sciences, Sverdlovsk

[Abstract] Combustion of solid organic wastes of low activity level from nuclear powerplants eliminates all but mineral ash, 50 to 100 times smaller in volume than the initial wastes. Organic materials represent 80 to 85% of the 200 kg of solid wastes with low activity level generated by a 1 MW nuclear powerplant each year. The use of combustion reduces this volume by 80%. Combustion devices must, however, burn the wastes as completely as possible without forming resinous substances which make the cleaning of smoke stacks difficult, must allow mechanized loading of wastes and unloading of the ash and reliable cleaning of flue gases to avoid radioactive contamination, even in case of an accident. A laboratory installation was used to study methods of combustion to eliminate dispersal of radioactive materials with the flue gas. It was found that during the initial period of combustion, large quantities of volatile thermolysis products were emitted. Increasing the consumption of air in combustion, increasing the temperature in the combustion zone and decreasing the size of each batch of material added to the combustor can reduce the formation of radioactive stack products.

Figures 4, references 7: 5 Russian, 2 Western.

[7-6508]

UDC 621.313.322-81:621.313.332

RANGE OF EXPEDIENT APPLICATION FOR SYNCHRONOUS INDUCTION TURBOGENERATOR

Moscow ELEKTRICHESKIYE STANTSII in Russian No 10, Oct 83 pp 38-41

KRIVUSHKIN, L. F., candidate of technical sciences, and CHEVYCHELOV, V. A., candidate of technical sciences, All-Union State Planning, Surveying and Scientific Research Institute of Power Systems and Electric Power Networks, Ukrainian branch

[Abstract] A synchronous induction turbogenerator, with longitudinal-transverse excitation and wide-range 2-channel regulation, offers higher stability during transients and better performance under heavy reactive loads than does a conventional synchronous turbogenerator. Its application in electric power generation and distribution systems at all voltage levels is analyzed here on the basis of cost effectiveness and system requirements, especially under conditions of prohibitive capacitive current drain for power factor correction. This analysis is particularly relevant to the design of new nuclear electric power plants ranging in size from 100-600 MW (110 kV) to 2000-6000 MW (750 kV) feeding overhead transmission lines or underground cables of corresponding critical lengths. Curves depicting blocks of power demand and ranges of generator  $\cos \phi$  over a 12-month period in the Southern Integrated Power Grid indicate that synchronous induction turbogenerators are particularly suitable for 750-1150 kV 1000-1500 MW power plants, where they should be optimally combined with conventional synchronous turbogenerators. Production of 1000 MW synchronous induction turbogenerators must be accelerated for equipping power plants in the European part of the Soviet Union on schedule, it being anticipated that in the 1990-95 period these turbogenerators will amount to 30-40% of all turbogenerators produced. Figures 3, table 1, references 4 Russian.

[29-2415]

THERMOMECHANICAL STUDY OF TGV-300 TURBOGENERATOR STATOR

Moscow ELEKTRICHESKIYE STANTSII in Russian No 10, Oct 83 pp 33-38

PIKUL'SKIY, V. A., candidate of technical sciences, RYABOV, Ye. V., candidate of technical sciences, TSVETKOV, V. A., doctor of technical sciences, and CHISTIKOV, A. A., engineer, All-Union Scientific Research Institute of Electrical Engineering

[Abstract] A comprehensive experimental-theoretical study was made of a TGV-300 turbogenerator in various modes of operation, of specific interest being the thermomechanical state of the stator under various conditions of cooling. The basic procedure was to measure strains and temperatures of individual structural components, end-coils and tie bolts being the most critical ones, followed by calculation of thermal stresses in accordance with the best fitting mathematical models. The measuring equipment included a total of 45 thermocouples and 57 temperature-compensated KF-5 strain gages, a TsTM-5 strain-gage resistance bridge, a PP-63 potentiometer, and an N-004M loop oscilloscope. Most parameters of the stator model could be determined quite accurately, except the stiffness of end-coil bracing and the friction between winding and core in slots. The results indicate that this bracing and the friction between winding and core in slots, The results indicate that this bracing contributes to heavier thermomechanical loading of the stator, the large temperature difference between winding and tie bolt (especially during short-circuits or rapid application of reactive load) contributing most to stresses and increasing them up to unsafe levels. Normal diurnal load variations were found not to cause excessive fluctuation of stresses, the amplitude of these fluctuations being almost independent of the temperature of the cold cooling gas. Placement of elastic spacers (spring washer) under the nuts of tie bolts is proposed as the most effective countermeasure ensuring reduction of thermomechanical stresses. Figures 5, references 5 Russian.

[29-2415]

OPERATION OF TURBINES WITH SEGMENTAL RADIAL BEARINGS

Moscow TEPOENERGETIKA in Russian No 4, Apr 83 pp 32-35

KOSYAK, Yu. F., candidate of technical sciences, and VISHNIVETSKIY, M. G., candidate of technical sciences, Industrial Association for Turbine Construction "Kharkov Turbine Manufacturing Plant"

[Abstract] Experimental and field data on the operation of K-500-240 turbines with segmental radial bearings have been collected and are now

evaluated. Such 500 MW turbines, built at the Kharkov Turbine Manufacturing Plant, are operating in various AES and GRES since 1979. The bearings, 300-560 mm in diameter, consist of load carrying segments which are lubricated through individual feed rather than in an oil bath and also cooled. These bearings were tested for vibration and temperature rise, at the babbitt surface and in the lubricating film, the total babbitt temperature being the main critical operating parameter. The failure rate so far has been very low, down to zero. Provisions for emergency oil feed and hydrostatic lifting of the turbine runner have been built into the system. The performance data indicate that these bearings contribute significantly to the economy of turbine operation. Figures 3, tables 2, references 5 Russian.

[9-2415]

UDC 662.997:697.644.1.001.2

#### DROP OF COOLANT TEMPERATURE IN INDIVIDUAL COMPONENTS OF SOLAR HEATING SYSTEM

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 16 Jun 82) pp 49-52

ABDULLAYEV, G. A., AVEZOV, R. R., AZIMOV, O. and KHOZHIYEV, K. B.,  
Physico-Technical Institute imeni S. V. Starodubtsev, UzSSR Academy of  
Sciences, and Samarkand State Institute of Architecture and Construction  
imeni M. Ulugbek

[Abstract] Temperature drops in low-temperature heating systems are very critical and must be minimized in each individual component of such a system. Here the mean temperature of the coolant in a solar heating system is considered. The drops of this mean temperature in the first loop and in the second loop, relative to the temperature of the radiation receiving surface of the heat collector are calculated on the basis of the corresponding equations of heat balance. Next is calculated the drop of the mean coolant temperature from first loop to second loop. Numerical data are given for an RSG-2 stamped steel radiator serving as heat collector in a solar heating plant. References 3 Russian.

[28-2415]

COMPREHENSIVE EVALUATION OF COST EFFECTIVENESS OF SOLAR ELECTRIC POWER PLANTS

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 18 Jul 82) pp 34-42

IBRAGIMOV, D. Yu. and FILATOV, A. I., State Scientific Research Institute  
of Power Engineering imeni G. M. Krzhizhanovskiy

[Abstract] The cost effectiveness of constructing a solar heating and electric power plant is evaluated on the basis of a compatibility analysis of its combination with a thermal electric power plant and a boiler-type heating plant, taking into account comprehensively economic factors as well as power requirements. Two variants of such a combination are considered and compared, assuming equal heating power and equal electric power respectively: 1) installation of all three plants begins at the same time, but normal operation of the solar plant begins earlier than that of the thermal power plant and earlier than the boiler heating plant; 2) installation of the solar plant begins later than that of the thermal power plant and later than that of the thermal power plant and later than that of the boiler heating plant, but normal operation of all three plants begins at the same time after completion of the entire project. Equations are set up for each variant covering fixed and variable costs of generating electric power and generating heat, as basis for comparing the two variants and optimizing them with respect to normalized annual total cost. These equations are relevant to conditions in Central Asia, assuming a type PTVT-100 boiler which runs on natural gas. Nomograms plotted for convenient numerical calculation of maximum economically worthwhile capital investment in a solar heating and electric power plant, depending on changes in various operating parameters, reveal that, as the time for constructing such a plant becomes longer, this maximum worthwhile investment in it increases for variant 1 and decreases for variant 2.

Figures 5, references 4 Russian.

[28-2415]

USE OF HEAT PIPES FOR HEAT COLLECTION AND TRANSMISSION IN SOLAR PLANTS

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 9 Dec 82) pp 27-29

ABIDOV, T. Z., GAZIYEV, U. Kh. and UMAROV, G. Ya., Physico-Technical Institute imeni S. V. Starodubtsev, UzSSR Academy of Sciences

[Abstract] A heat pipe has been designed for use as heat collector in solar plants. It has a siphon rather than capillary construction with uniform wall thickness over its entire length. Its 0.7 m long evaporation zone, placed in the focal plane of a parabolocylindrical concentrator, is

connected to the solar heat cell. Its 0.2 m long condensation zone, separated from the evaporation zone by a 0.15 m long adiabatic zone, is connected to the general-purpose heat collector which contains the working fluid. The heat pipe is in an inclined position so as to facilitate gravity return flow of the condensate into the evaporation zone. In a preliminary study of its thermotechnical characteristics under laboratory conditions, the prototype was tested with water as the working fluid and an electric heater coil wrapped around the evaporation zone. The amount of water was sufficient to completely immerse the evaporation zone in the presence of vapor and condensate. The efficiency of this heat pipe was measured as function of the input power at constant rate of water flow (10 and 20 l/h respectively) through the calorimeter with the inlet temperature varied over the 50-80°C range. A maximum efficiency reaching and exceeding 90% was attained at an input power of 300 W or higher.

Figures 3, references 2 Russian.

[28-2415]

UDC 621.472

#### POWER PLANTS OF MODULAR CONSTRUCTION WITH QUASI-PARABOLOIDAL CONCENTRATORS OF SOLAR ENERGY

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 1 Jun 82) pp 17-22

BARANOV, V. K., State Institute of Optics imeni S. I. Vavilov

[Abstract] Solar electric power plants with parabolocylindrical concentrators are not as efficient as those of the tower type and, therefore, another modular construction has been considered. The idea is to concentrate solar energy on a small spot and to locate the power plant, which consists of a heat collector and a Stirling, Brayton, or Rankine engine with an electric generator, near that spot. The solar energy concentrator is the most expensive component in such a system, it must be designed and built to perform like a paraboloidal mirror. Twenty-two modifications of such a concentrator are being considered that fall into 3 basically different groups and are in various stages of development. The first 13 concepts are based on using plane, spherical, or double-curvature facets made of silicate glass with silver backing or polymer film with aluminum coating. The next 4 concepts are based on using aluminized polymer film and forming it by means of air inflation. The last 5 concepts are based on using plane or cylindrical Fresnel mirrors, or a Fresnel lens. The status of these developments is: 3 concentrators (spherical facets, Fresnel mirrors) already in production on a small scale, 1 concentrator (spherical facets) already in service, 8 concentrators in experimental prototype stage, 4 concentrators in design stage, 4 concentrators ready for design, and 2 concentrators only found to be technically feasible.

Table 1, references 24: 1 Russian, 23 Western.

[28-2415]

TRIAL OPERATION OF PROTOTYPE OF 'RZDPOM'-SERIES ARC-QUENCHING REACTORS WITH AUTOMATIC REGULATION

Moscow ENERGETIK in Russian No 6, Jun 83 pp 21-23

PETROV, O. A., candidate of technical sciences, SEMENOV, V. V., engineer, ROGATYKH, P. N., engineer, VINOGRADOV, V. G., engineer, and ISAYEV, Yu. V., engineer, Chelyabinsk Polytechnic Institute; Chelyabinsk Urban Electric Power Networks

[Abstract] The prototype of an RZDPOM 250 kVA ~ 5 kV arc-quenching reactor with stepless regulation, built in accordance with Government Standard 19470-74, has been installed in the "Vostochnaya" substation of the Chelyabinsk Urban Electric Power System for Trial operation. The reactor is connected to the neutral on the primary side of a TM-320/6 transformer and its movable core is driven by an AOLS-2-31-4F2 1.3 kW electric motor through a worm gear with a unidirectional clutch. A capacitive-type automatic regulator has been developed at the Chelyabinsk Polytechnic Institute for compensating the capacitive current and regulating that compensation on the basis of measured capacitive network admittance during normal operation, while interlocking the system during single-phase short-to-ground. The original Textolite pinion gear of the motor has been replaced at the Moscow Electromechanical Manufacturing Plant with a brass one more adequate for regulation of the gap width in the magnetic circuit of the reactor during single-phase short-to-ground and also more moisture-resistant. The essential performance characteristics of the reactor are its full current and active as well as reactive power as functions of the potentiometer voltage proportional to the change of gap width in the magnetic circuit, the curve of reactor current intersecting the curve of residual current at the fault location at some magnitude of this voltage. The design of the RZDPOM reactor was debugged on the basis of field test data on its performance. Figures 2, references 1 Russian,

[11-2415]

AUTOMATION OF HEATING AND COOLING OF INDIVIDUAL TURBINES

Moscow ENERGETIK in Russian No 9, Oct 83 pp 5-7

MIKHALENOK, S. A., KURILIN, L. A., SHIRYAYEV, S. S., ROMANOV, L. K. and KOBZAR', Yu. V., engineers, Belenergoremnaladka

[Abstract] The authors' organization has developed a method for speeding up heating and cooling of turbine elements. Cooling is achieved by reduction of the temperature of the steam fed to the turbine by mixing low-potential and fresh steam in a special mixing device. Mixing of fresh steam from the main steam line and low-potential steam from the collector at 8-13 kgf/cm<sup>2</sup>, 280°C occurs in a mixer which is a thermal compressor in which the fresh steam injects the steam from the takeoff, redistributing the flow of steam

entering the mixer. The total flow of steam to the turbine is maintained approximately constant during transient modes and is determined by the throughput capacity of the turbine steam lines participating in the process. Stages in the process of warm-up and cool-down are briefly described. Graphs of steam flow and connection diagrams of turbines and associated valves are presented. Automatic control of the process assures optimal change in temperature of the steam, avoiding undesirable temperature disturbances and assuring uniform warm-up or cool-down of turbine elements, allowing optimal programs of variation of temperature during transient processes. Testing of the system has shown significant improvement in the quality of transient processes in comparison to manual control, increasing turbine reliability. Figures 4.

[12-6508]

UDC 621.317.7.002:62-50

CLASSIFICATION OF HOLDING JIGS FOR OBJECTS OF ROBOTIZED ASSEMBLY

Moscow PRIBORY I SISTEMY UPRAVLENIYA in Russian No 8, Aug 83 pp 34-35

VERTOGRADOV, O. N., candidate of technical sciences, KROLIK, D. L.,  
engineer, and POYDA, M. P., engineer

[Abstract] Holding jigs are essential to smooth performance, by industrial robots, of successive technological operations at various levels of automation. For the purpose of formalizing a consistent terminology, a classification of holding jigs is proposed which applies particularly to assembly and other processing of miniature product parts. A holding jig is defined as a transfer device and characterized by five indicators encodable so that up to  $3 \cdot 2 \cdot 3 \cdot 1 \cdot 3 + 3 \cdot 2 \cdot 3 \cdot 1 \cdot 4 = 108$  different holding jigs can be covered. The first digit indicates the degree of usage (single, multiple, combination). The second digit indicates the number of type sizes a jig can hold (one, many). The third digit indicates the correspondence (full, partial, none) between the relative positioning of parts in the jig and their relative positioning in the assembled product, this indicator being particularly important for products with flanges. The fourth digit indicates whether or not parts of the same type size touch one another in the jig. The fifth digit indicates the type of jig construction. The most common form of a holding jig is a box, usually with windows, such as a multipurpose or compound one. Another form is a set of pins on a base, both this one and the box form belonging to those where the parts touch one another. The four main forms of holding jig where parts do not touch one another are a harness, a band, a honeycomb, and a strip. Figures 9, references 7 Russian.

[33-2415]

CONTROLLABLE MOVEMENTS OF ELASTIC MANIPULATOR WITH THREE DEGREES OF FREEDOM

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: MEKHANIKA in Russian Vol 36, No 3, Mar 83 (manuscript received 22 Jun 82) pp 12-20

GUKASYAN, A. A., Institute of Problems in Mechanics, USSR Academy of Sciences

[Abstract] The kinematics and the dynamics of a programmable automatic manipulator are analyzed, allowing for elastic compliance of its single link and regarding a perfectly stiff one as a limiting case only. A manipulator with three degrees of freedom is considered, one to which the linear theory of thin straight beams is applicable. The equations of equilibrium for such a manipulator carrying a load are derived in generalized Lagrange coordinates from corresponding expressions for kinetic energy and potential energy. For deriving the equation of kinematic control, the manipulator is assumed to be driven by three motors according to prescribed laws of motion in terms of the three generalized coordinates as functions of time. The solution of the corresponding differential equation of vibrations for a mechanical system with slowly varying parameters and with given initial conditions is used to calculate the two forces and one moment necessary for implementation of the programmed movements. For deriving the equation of dynamic control, the manipulator is assumed to be driven by three motors in accordance with prescribed laws governing the two forces and one moment as functions of the three generalized coordinates and time. The solution of this equation is used to determine the motion of the manipulator with load which will implement this mode of control. The analysis concludes with control of the two forces and one moment on the manipulator link for a prescribed motion of the load. The author thanks F. L. Chernous'ko for formulating the problem, also L. D. Akulenko and N. N. Bolotin for helpful comments. Figure 1, references 4 Russian.

[23-2415]

UDC 681.7

MILLING OF SPHERICAL ZONES IN PARTS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 9, Sep 83 (manuscript received 24 Oct 81) p 36

MIROSHNICHENKO, V. D. and KOCHURA, G. P.

[Abstract] Fabrication of spherical surfaces by end milling requires a predetermination of the process parameters for producing a spherical zone. The authors have established a relation for the angle  $\alpha$  at which the geometrical axes of mandrel and cutter shaft must intersect to ensure minimum labor and minimum total cost. This relation is

$$\alpha = \sin^{-1} \frac{r}{R} + \sin^{-1} \frac{\alpha}{R}$$

(R- radius of spherical surface to be machined, r- radius of cutter,  $\alpha$ - base

radius of boss not to be machined, + corresponding to a boss outside the cutter point trajectory and to a boss under the cutter face respectively). This formula applies to milling of large spherical surfaces with a small cutter, as in fabrication of a die for molding Fresnel lenses or in preliminary aspherization of parts with central axis of symmetry. Figures 2, reference 1 Russian.

[31-2415]

UDC 621.311.22.62-5.681.2

NEW EQUIPMENT COMPLEX 'KASKAD 2' FOR AUTOMATIC CONTROL

Moscow TEPLOENERGETIKA in Russian No 10, Oct 83 pp 5-9

GAVRILOV, B. P., engineer, SLAVIN, A. A., candidate of technical sciences, and SHAPIRO, Yu. M., candidate of technical sciences, Moscow Thermal Automation Plant

[Abstract] The "Kaskad" automatic control equipment complex produced for some time at the Moscow Thermal Automation Plant has been recently updated and supplemented. The new "Kaskad 2" complex consists of 3 regulating modules (R017 for PID-regulation with continuous output signal, R027 for PID-regulation with pulse output signal and with servomechanism action, R028 for PI-regulation with pulse output signal and with servomechanism action), 4 deflection signal shaping modules (I001 for d.c. signal with galvanic separation of four inputs, ID001 for up to three differential-transformer transducer signals, IS001 for up to two impedance transformer signals, IT002 for up to two thermoelectric transducer signals), 7 static signal conversion modules (A001 for galvanic separation of signals from two independent channels, A005 for summing and scaling, A035 for multiplying, dividing, squaring, or square-root extracting, A003 for analog-to-relay conversion of signal difference from two inputs, A005 for piecewise-linear approximation, F001 for voltage-to-frequency conversion with two inputs for each signal polarity, F003 for proportional conversion of up to three input current signals), and 3 dynamic signal conversion modules (D005 for differential, aperiodic, or integral conversion of signals from two independent channels, analog, 3-step discrete, or analog-discrete control of proportionality factor and time constant, D007 for integration of frequency signal with subsequent digital-to-analog conversion, with fast or slow forced change of output signal, for controllable bilateral signal limiting with audio-visual indication, and for data storage and recovery). These modules are variously combined into 11 different functional units. The first production set of this complex has been operating in the Konakovo GRES since 1982. Figures 7, tables 5.

[30-2415]

UDC 681.7.05

EQUIPMENT FOR PERFORMING SURFACES OF OPTICAL PARTS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 8, Aug 83  
(manuscript received 7 Dec 82) pp 52-58

BALABANOVICH, V. A., VERESHCHAKO, I. N., DERBENTSEV, V. T., MEDVEDEV, I. N.,  
KONOVALOVA, A. I. and MLECHKO, V. B.

[Abstract] A survey is made of available equipment built by foreign manufacturers for mechanical treatment of optical parts. This survey covers spraying machines ("Wilhelm Bothner", "Meyer & Burger A. G.", "Dama", "Erich Dern", "Leico"), circular-grinding machines ("Dama", "Leico", LOH), universal grinding machines ("Wilhelm Bothner", "Rogers & Clarke", "CMV Interamerica", "Dama", "Kyoritsu Seiki", LOH, "R. Howard Strasbangu"), and drilling machines ("Meyer & Burger A. G.", "Erich Dern"). Figures 9, tables 12, references 10 Western.

[34-2415]

UDC 666:1.031

POWER CONTROL OF INDUCTION EQUIPMENT FOR FOUNDRY OPTICAL GLASS IN ARRAY OF PLATINUM CRUCIBLES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 8, Aug 83  
(manuscript received 5 May 82) p 59

RYS'KOV, V. S., CHUDNOVSKIY, V. S. and KUDRIN, N. A.

[Abstract] Founding optical glass in arrays of platinum crucibles yields a high-quality product, especially in a continuous zonal process. These crucibles are best heated electrically by induction, with the power for each individual crucible controlled through temperature feedback. Such a control system must combine high reliability over long periods of time, up to several months, with precise maintenance of temperatures in the crucibles. A system developed for this application operates with a central power supply through a thyristor-type frequency converter for 2-phase or 3-phase loads, with automatic power and temperature control for each crucible independently. The power is controlled at the frequency converter, by means of a rectifier and an inverter, both the fundamental component and the third harmonic of the inverter output current as well as the rectifier d.c. output voltage being adjusted until the mismatch signal is reduced to zero. Other components of this system include thermocouples affixed to the side walls of the crucibles and acting as temperature transducers, and a high-precision regulator with measuring devices in each control channel. The crucibles are protected against overheating due to equipment faults by KSP-3 devices also used for visual inspection. The temperature of a crucible can be maintained constant within  $\pm 1^{\circ}\text{C}$ . Figure 1, reference 1 Russian.

[34-2415]

SMALL-SIZE MEASURING GAUGES FOR METAL CUTTING MACHINE TOOLS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
(manuscript received 4 Nov 82) pp 19-21

LEVIN, B. M., LYAPKOV, V. N., MYASNIKOV, Yu. A. and KIRSANNOVA, L. N.

[Abstract] Recently two new models of suspension-type optical measuring gauges have been developed with a 0.01 mm scale division, for measuring displacements of movable parts in metal cutting machine tools. The first one is the IG-98 consisting of an STs-80 incandescent lamp, a light filter, two reference rulers, two objectives, a light splitter cube, four plane mirrors, two condenser lenses, a graduated circle and a magnifying glass. The second one is the IG-119 consisting of an STs-61 incandescent lamp, a light filter, a rectangular prism with cover, two reference rulers, two objectives, a light splitter cube, one mirror, one condenser lens, a cylindrical shield and a magnifying glass. Both are packaged in rectangular cases with a viewing window on top, two dial knobs, and a socket for the connecting cable. A complete accuracy analysis of both instruments indicates that two out of the seven principal error components are negligible, namely the angular error of the null adjustment guides and the temperature error referred to the plane of one of the reference rulers. The total error of the IG-98 and of the IG-119 is 2.4  $\mu\text{m}$  and 3.36  $\mu\text{m}$  respectively. Figures 4, table 1, references 4 Russian.

[2-2415]

FABRICATION OF TURBINE PARTS WITH TRANSPORTABLE TOOLS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 4, Apr 83 pp 43-46

KHOKHLOVA, T. I., engineer, and KATS, R. G., engineer

[Abstract] Lines of transportable machine tools have been developed in the United States, the FRG, and the GDR for "frameless" fabrication of turbine parts, especially large ones with hardly any limitation on size, and their assembly in situ. This method has been found to be more efficient and economical than transporting the parts from one machine tool to another and to assembly, the cost of transportable machine tools being much lower than that of necessarily heavier stationary ones with required foundations. These machine tools include lathes for turning, boring, milling, grinding, drilling operations to be performed outside or inside the turbine housing. Two items of interest are the model UBV160 transportable combination tool with lathes for all these operations built by the Reimann GmbH in the FRG and the transportable machine tool on a special base plate for all assembly operations, including control of axial and radial play, blade setting and trimming,

and runner banding, built by the GEORG GmbH in the FRG. Figures 4, references 10: 1 Russian, 9 Western.  
[14-2415]

UDC 621.914.7:621.833

#### NEW TECHNOLOGY OF FINISH CUTTING TEETH IN LARGE GEAR BLANKS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 4, Apr 83 pp 27-29

OVUMYAN, G. G., candidate of technical sciences, LIPATOV, Yu. A., engineer, and KHURKHRIY, S. A., candidate of technical sciences

[Abstract] A new technology has been developed for finish cutting teeth in large gear blanks to ensure the necessary precision and surface smoothness. An analysis of the cutting process relative to gear blanks with a hardness of  $bhn < 320$  has revealed that the wear on the back surface of the tool is determined essentially by the length of the cutting (friction) path. The known relations characterizing the dependence of the length of that path on other process parameters (tool radius, tool travel, depth of cut, angle of tooth profile) and the dependence of the depth of wear on the length of that path serve as the basis for optimizing the process. These considerations have resulted in the design of a double-thread cutter consisting of two cutting blades screwed into an arbor, their orientation relative to the cutter axis adjustable by means of support plates and a pin. The finish cutting can be combined with preliminary rough cutting and, furthermore, this cutter is more simple to produce and operate than a multithread cutter. Figures 4, tables 2, references 2 Russian.

[14-2415]

UDC 621.822

#### REDESIGN OF GUIDE BEARINGS IN 52V-11 PUMPS OF GOLODNAYA STEP' PUMPING STATIONS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 4, Apr 83 pp 10-11

VALIAKHMEDOV, I. S., engineer, KOLESNIKOV, B. I., engineer, and SHIFRIN, L. M., engineer

[Abstract] The guide bearings in several 52V-11 pumps of the Golodnaya Step' (Tadzhik SSR) pumping stations have been redesigned so as to eliminate the widening of radial clearance as a result of lining wear and thus minimize shaft wobble. The pressboard lining has been replaced with rubber cladding of the six bearing segments secured by flat-head set screws, a lower cuff seal under a steel retaining ring, and an upper gland seal. Provisions have been included for convenient assembly and disassembly of the bearing segments

as well as for automatic regulation of the radial clearance between bearing segments and shaft journal. The performance of these new bearings was found to be so much better than that of the existing ones that their installation in all ten pumps in each pumping station can be recommended. Figure 1.

[14-2415]

UDC (621.822.5:621.165).001.4

#### AXIAL BEARINGS WITH LEVER-TYPE EQUALIZER SYSTEM

Moscow ENERGOMASHINOSTROYENIYE in Russian No 4, Apr 83 pp 8-10

ZARETSKIY, Ye. I., candidate of technical sciences, SEREZHKINA, L. P., candidate of technical sciences, and TOMKOV, Yu. P., engineer

[Abstract] In order to realize the maximum load capacity of a segmental axial bearing, it is necessary to equalize the load over all segments. This is achieved by means of a lever system in Kingsbury thrust bearings produced at the Kharkov Turbine Manufacturing Plant and operating in large steam turbines. Each bearing shoe rests on an "upper" lever arm, the "upper" lever arms under each two adjacent shoes being balanced on a "lower" lever arm linking both until the loads on all shoes around the collar have been equalized and the effect of inevitable manufacturing or installation imprecision thus eliminated. The effectiveness of this method is demonstrated on 8-shoe and 10-shoe bearings with the ripple of the load distribution and the skew of the temperature distribution smoothed out almost completely by the action of levers. Some elastic deformation of the levers occurs as load is applied to the bearing, the magnitude of this deformation becoming comparable with that of the axial shaft movement under heavy thrust loads. Figures 4, references 2 Russian.

[14-2415]

UDC 681.7:621

#### EXPERIENCE IN USE OF OPTICAL THEODOLITE FOR MACHINE CONSTRUCTION

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 6, Jun 83 pp 33-35

SHERESHEVSKIY, L. M.

[Abstract] An optical theodolite, an instrument of small size and weight featuring a high-precision horizontal dial, has been successfully used in production of forging and pressing equipment at the Voronezh plant. Such a TV-1 theodolite, together with a contact-type indicating device and a mechanism for centering the machined part, is included in a turret goniometer for angular alignment and control of cutting operations. Its micrometer has 1" scale divisions, the instrument is designed to give readings with a high degree of stability and reproducibility with the standard deviation of one

measurement not exceeding 5". It is particularly useful in production of parts with variable spacing and cross section of grooves or slots, including curvilinear ones. With a universal adapter plate on which guide prisms and an interchangeable gauge pin are mounted, this theodolite can also be used in production of large bevel gears: the same instrument for a wide range of gear sizes, diametral pitches, and tooth profiles. Using the maximum of standard components, this theodolite can be easily assembled at any manufacturing plant. Figures 2, table 1, reference 1 Russian.

[39-2415]

UDC 621.9.06-229.3-82-85

#### PNEUMOHYDRAULIC DRIVE

Moscow MASHINOSTROITEL' in Russian No 8, Aug 83 p 46

NEMKOVICH, A. N., engineer

[Abstract] A novel pneumohydraulic drive has been invented (USSR patent disclosure No 973,956) for disengaging a machine tool upon loss of sealing in its high-pressure cylinder. The main component of this drive is a hydraulically (oil) driven piston compressing or expanding air inside a cylindrical cavity. Through two controllable valves, one under the piston and one above the piston, the latter drives a 3-position distributor ("disengagement", "preliminary re-engagement", "final re-engagement") with the aid of single-stage or 2-stage pneumohydraulic transducers. The performance of this drive needs to be further evaluated for various applications.

Figure 1,  
[42-2415]

UDC 621.97.06:621.73.004.67

#### CLUTCHLESS MECHANISM FOR ENGAGEMENT OF FORGING PRESS

Moscow MASHINOSTROITEL' in Russian No 8, Aug 83 p 18

KOZHEVNIKOV, V. A., candidate of technical sciences, PEKELIS, G. D., candidate of technical sciences, and LAZAREV, R. V., engineer

[Abstract] A mechanism for engagement of forging presses is described in which the clutch has been replaced with an electromagnetic contactless coupling. The mechanism includes an electric motor with a flexible flywheel, a crankshaft with eccentric, and a connecting rod. The coupling consists of electromagnets (coils wound on cores) with return springs acting on the electromagnet cores through pins, adjustable nuts, disks, and tapered actuators. The coupling is controlled from a switchboard for the electromagnet coils.

Automatic cutout of the actuators is provided in the case of overload. Elimination of the clutch saves 20-55% energy in starting and stopping, eliminates impact loads, reduces the noise level by a factor of 2.6-3, reduces consumption of compressed air by a factor of 5-17, lengthens the life of a press, and contributes to a more economical design and production of presses. This mechanism is already used with K2118B, PKN-10, KD2326, KA2028, K116, K117, K2330B, K217 presses and will be incorporated in KD2330 K3132A, K8540 presses. Figure 1.

[42-2415]

UDC 621.914.7-529;621.992.4.061.004.69

#### MILLING MACHINE WITH NUMERICAL PROGRAMMED CONTROL FOR CUTTING TEETH

Moscow MASHINOSTROITEL' in Russian No 8, Aug 83 pp 16-17

USUBAMATOV, R. N., candidate of technical sciences

[Abstract] A universal milling machine for gear cutting with slotting head, planing head, turnable spindle and numerical programmed control has been developed on the basis of analysis and synthesis of tool and blank motion along three space coordinates. It is designed in accordance with appropriate kinematic relation governing the gear cutting process. Numerical control is effected by means of an indexing plate with pins and covers a wide range of gear shapes and sizes. This machine replaces several special-purpose gear cutting machines used in small-scale production. Figures 2.

[42-2415]

UDC 621.9.06-8

#### NOVEL DRIVES FOR MACHINE TOOLS

Moscow MASHINOSTROITEL' in Russian No 8, Aug 83 pp 10-11

PESTUNOV, V. M., candidate of technical sciences

[Abstract] Three novel drives for machine tools have been invented. The electric drive for a drill (USSR patent disclosure No 407652) includes a differential and a worm gear for converting rotary motion to translatory motion, automatic feed control under load being effected by adjustment of the driving torque through adjustment of the excitation current in the coil of the electromagnetic coupling. The two-speed electric drive for a hone (USSR patent disclosure No 795871) simplifies the construction and the operation of such a machine tool, controlling its reciprocating motion with the aid of an auxiliary motor coupled to the main one through a worm gear with the two pinions threaded in opposite direction. The hydraulic drive for a drill (USSR patent disclosure No 846801) controls the forward motion with

the aid of a pump which drives two oppositely rotating motors coupled through a worm gear, a fluidic splitter ensuring the proper ratio of their speeds and synchronism of both causing the drill to remain in position. Here the control is automated by means of feedback from a velocity transducer through an amplifier and a comparator to a servomotor driving the fluidic splitter, the comparator being programmed externally. The worm-gear couplings in the last two drives are nonself-braking. Figures 3.

[42-2415]

#### CONSERVATION OF TURBINES BY INHIBITED AIR

Moscow ENERGETIK in Russian No 9, Oct 83 pp 9-10

KOSTRIKINA, Ye. Yu., candidate of technical sciences, PERSIANTSEVA, V. P., doctor of chemical sciences, ZAMYATINA, O. V., KUZNETSOVA, Ye. V., and MIKHAYLOV, N. K., engineers, All-Union Institute of Turbines, imeni F. E. Dzerzhinskiy; Institute of Physical Chemistry, USSR Academy of Sciences; Kashia GRES

[Abstract] Conservation ("mothballing") of turbines is presently performed either by blowing through hot air or by applying volatile corrosion inhibitors to the surfaces of the turbine. The method of conservation of turbines using volatile inhibitors has now been modernized. According to the new method, an entire turbine which is to be put out of service for some time is broken down into several sections and corrosion inhibitors are blown through each section in sequence. This allows better coating of the entire metal surface. The process also requires degreasing of wash water during demothballing. In a further development of the method, inhibited air is used for conservation. The distinguishing feature of this method is the use of acclosed system eliminating the possibility of leakage of inhibitors into the surrounding environment and thus virtually eliminating losses. The inhibitor used is a compound developed at the Institute of Physical Chemistry, USSR Academy of Sciences, which has high protective effect for ferrous and nonferrous metals. The use of inhibited air allows corrosion inhibition in machines with very narrow gaps with corrosion inhibiting substances. Conservation of a turbine by the method requires only about a half hour to achieve a sufficient protective concentration of the inhibitor within the turbine. Bringing the turbine back into service requires only that it be blown out with air, absorbing the inhibitor residue with silica gel.

[12-6508]

UDC: 621.039.53

SPECIFICS OF MANUFACTURE OF DEVICES USED IN VVER-440 NUCLEAR REACTORS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 7, Jul 83 pp 24-27

BOGDANOV, Yu. P., KOVALENKO, B. I. and PETROV, Ye. K., engineers

[Abstract] Water-cooled, water-moderated reactors such as the VVER-440 represent a significant portion of the Soviet nuclear power generation effort. The devices used within the body include shafts suspended on the flange of the body, shaft bases and barrels within the shafts, units of protective pipes installed on the barrel with the core. These units are metal structures made of corrosion resistant steel. Methods of manufacture and quality control are briefly described. Quality control includes testing of chemical composition and mechanical properties, metallographic studies, determination of intercrystalline corrosion tendency, ultrasonic and capillary flaw detection, x-ray examination of welds, testing of heat treatment and geometry. The final stage in manufacture of the devices to be contained in the reactor body is assembly with a model body on a special test stand. The purpose of this assembly is to check under plant conditions the assembly of the units, check the processing of the face elements and perform fitting operations depending on the specifications for the devices. Figures 4, references 2 Russian.

[17-6508]

UDC: (621,165+621,438)-62-523.3

HIGH RELIABILITY MECHANICAL-HYDRAULIC CONVERTER

Moscow ENERGOMASHINOSTROYENIYE in Russian No 7, Jul 83 pp 15-16

VELLER, V. N., doctor of technical sciences and LITVINOV, V. S., engineer

[Abstract] The F. E. Dzerzhinskiy Institute of Technology has developed a mechanical-hydraulic converter, the reliability of which is determined by the complete absence of friction couples and the balance of hydraulic forces. The device is diagrammed and described. Results of testing of an experimental model at the Institute are presented. A graph illustrates the variation in influence of change in initial pressure on position of moving portion.

Figures 3.

[17-6508]

INVARIANT SYSTEM OF TECHNOLOGICAL PREPARATION OF PRODUCTION

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 83 pp 32-34

ZAL'TSMAN, L. I., and KYUTTNER, R. A., candidates of technical sciences, and ROGINSKAYA, B. I., engineer

[Abstract] An integrated system has been developed and is now gradually being introduced, consisting of two great segments: systems support and functional subsystems. The systems support segment includes the metamonitor system, data base and general applications programs; functional subsystems include the information retrieval, blank planning, technological process planning, control program development and equipment design sections. A structural diagram of the integrated system for preparation of production is presented. The metamonitor system is said to have several advantages over standard operating systems: reduction in labor consumption by a factor of 10 to 20, dynamic distribution of RAM for programs and data structures, utilization of dynamic files with up to 8 levels of subfile structures and modeling of virtual memory, utilization of associative data structures, timely introduction of alterations and additions to the subsystem, performance of jobs in stages utilizing memory equal to the maximum length of memory for a single instruction, possibility of dynamic attachment and detachment of terminals. The data base is briefly described. The system is suitable for use in production facilities of all types manufacturing parts of any class including solids of revolution, solid parts, hydraulic turbine blades, circular sections and other shapes. Further development of the system planned includes the use of smart terminals, and increases in levels of automation in the technological process planning subsystem by the inclusion of pattern recognition units.

[15-6508]

MECHANIZATION AND AUTOMATION OF PRODUCTION PROCESSES IN TURBINE BUILDING

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 83 pp 22-24

SLOBODYANYUK, V. P., engineer

[Abstract] Specialists at the All-Union Institute of Planning and Technology of Energy Machine Building are working on the problem of mechanization and automation of production processes. One of the major technological processes being worked on is the production of welded units. At the present time the Institute has designed a centralized cutting and manufacturing shop in use at several metallurgical plants, clamping devices for materials hoists based on permanent magnets, a program controlled installation for driving shaped apertures in welded diaphragm rims and an automated system for

planning technological processes involved in manufacturing operations. Even in the manufacture of such individualized devices as turbines, mechanization and automation of production processes are economically justified. During the 11th Five Year Plan, the Institute will continue to develop progressive technological processes and equipment for precise shaping of turbine blade blanks, mechanical working of parts of steam, gas and hydraulic turbines, as well as nuclear powerplant turbines.

[15-6508]

UDC: 621.224-253.6:621.9.06-529

MANUFACTURE OF DRIVE WHEEL VANES FOR HYDRAULIC TURBINES ON PROGRAM CONTROLLED MACHINE TOOLS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 83 pp 20-22

SMIRNOV, S. M., engineer

[Abstract] Previously in manufacturing the vanes for model drive wheels, copying milling machines were used. With a new technology now in use, model 6R13F3 machines with model N-33-1M numerical program control units are used. This has required the development of a software system based on methods and algorithms of approximating curves and surfaces with spline functions developed at the Institute of Mathematics, Siberian Branch, USSR Academy of Sciences. An AKI translator is used to develop the control programs and new modules. The technology of working of vanes from rectangular bars worked on 6 sides and having two vertical apertures to provide a base is briefly described. Models of vanes and drive wheels type RO-833 and RO-810 have been manufactured by the new process. The surfaces of vane models for the RO-833 wheel to be used at the Sayano-Shushenskaya hydroelectric powerplant are illustrated. Introduction of the new technology involving program controlled machines has increased quality and uniformity of vane surfaces while improving hydraulic characteristics of the drive wheels and the turbine as a whole. The production cycle has been speeded up by a factor of 3 to 4 and a savings of 25,000 rubles per year has been achieved.

[15-6508]

UDC: 621.90-529

USE OF PROGRAM CONTROLLED MACHINE TOOLS TO AUTOMATE AND MECHANIZE  
PRODUCTION PROCESSES IN PIPE MANUFACTURE

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 83 pp 17-20

OGURTSOV, A. P., and SKVORTSOV, S. B., engineers

[Abstract] The Leningrad Metallurgical Plant is a pioneer in development of modern equipment. Program controlled machine tools have been in use here since 1971, with more than 150 such units now in operation. Economic results of introduction of several of these machines are described. However, the rate of introduction of program controlled machines is frequently slowed down due to the great amount of labor required to prepare the control programs for processing of complex parts. Computer systems such as the PDP-11/05 acquired by the plant are used in development of the programs. This machine has been used to develop a software system applicable for many types of domestic and imported program controlled machines. During the present 5 year plan, the plant is to introduce new methods of processing and progressive technological equipment, including equipment for mechanization of labor-consuming processes, allowing automation of the working of most of the major types of parts and units of turbines.

[15-6508]

UDC: 621.646.2

HYDRAULIC CHARACTERISTICS OF REDUCTION INSTALLATION VALVES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 83 pp 14-16

SURNOV, A. V., candidate of technical sciences, NIKITINA, L. V.,  
SITNYAKOVSKIY, Yu. A. and TEN, L. G., engineers

[Abstract] A wind tunnel has been created at the Chekhov Power Machine Building Plant. Air is fed into the 250 mm diameter wind tunnel by a 2-stage compressor with a capacity of 41 m<sup>3</sup>/min (s.t.p.) with a head of 11.8 kPa. The test stand has been used to test full scale models of reduction valves. Five types of valves for maximum saturated steam flow rates of 45 to 160 t/hr, pressure 4.5 to 5.4 MPa, were tested. The test data were found sufficient for reliable profiling of the throughput cross sections of reduction valves. Figures 4, references 5 Russian.

[15-6508]

UDC: 621.941.2-529

GROUP TECHNOLOGY FOR WORKING TURBINE DRIVE WHEEL DISKS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 3, Mar 83 pp 26-28

GLUKHIKH, V. K., SKVORTSOV, S. B., SIDOROV, V. A. and KOKAREV, N. V.,  
engineers

[Abstract] The shortcomings of the existing technological process of manufacturing disks to be used as the hubs of low pressure steam turbines include the use of inaccurate equipment, low-speed processing modes, high labor consumption, significant heating of parts and the impossibility of precise working for this reason. In developing a group technological process, mechanical working of the disk was divided into two main groups, differing in the method of attachment of the blades to the rim. Disks are worked using a program-controlled model DFM-30 NCC-2200/1000 lathe, cooled with a large quantity of cutting fluid with chips removed by a chip transporter and dumped into containers. Designs of disks were standardized and the design of individual elements simplified. Progressive cutting tools with hard alloy plates were used. Productivity of labor was increased by 30 to 50%, consumption of specialized cutting and measurement tools reduced and less skilled workers would be used in the process. Significant savings of time can be achieved only by working 4 to 5 disks in a batch. Figures 2.

[13-6508]

UDC: 62-505

SYNTHESIS OF OPTIMAL CONTROLS FOR REAL-TIME LINEAR DIGITAL SYSTEMS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY PRIBOROSTROYENIYE  
in Russian Vol 26, No 8, Aug 83 (manuscript received 19 Jan 83) pp 32-36

GERASIMOV, A. N. and IVANOV, V. M.

[Abstract] The solution of the problem of optimizing linear digital systems which are optimal in terms of sum-of-squares performance criteria leads to Riccati's difference equation. The problem of the analytical construction of controls which are optimum with respect to the generalized work criterion, consisting of solving a linear difference equation in reverse time, has been solved for the class of digital systems. The present study proposes an algorithm with a prediction model based on this criterion which allows controls to be synthesized in real time. References 3 Russian.

[6-6508]

UDC: 681.513.5

## CONSTRUCTION OF HIGH SPEED GUARANTEED REGULATORS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 8, Aug 83 (manuscript received 22 Dec 82) pp 36-41

KOLESNIKOV, A. A. and CHERNYSH, P. I., Taganrog Radiotekhnical Institute  
imeni V. D. Kalmykov

[Abstract] The construction of guaranteed control systems for objects with variable parameters operating with incomplete information about parameters and perturbations is an important problem in optimal control theory. The present study examines a procedure for synthesizing such systems for certain objects. The problem of guaranteed control with respect to the synthesis of high speed regulators is specified; formulas are derived which can be used to identify a "stationary" object which is characterized by the poorest performance indicators in terms of speed. The procedure of constructing a high speed guaranteed regulator for an object thus consists of defining the analytical parameters and perturbations by the method explained in the study, and then synthesizing a control principle which is optimal in terms of speed in accordance with methods developed elsewhere. The true speed of the system for parameters and perturbations other than those calculated will be higher than for movement along a synthetic hypersurface, which gives rise to movement in the "slipping mode". The method can be used for selecting the parameters of the slipping hypersurface for systems with discontinuous controls. The method provides the best transient processes in terms of speed and invariance to changes in the parameters and perturbations.

References 8 Russian.

[6-6508]

UDC: 62-50

## MODAL SYNTHESIS OF MULTIDIMENSIONAL PI-REGULATORS FOR OBJECTS WITH INERTIAL SECTIONS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 8, Aug 83 (manuscript received 12 Nov 82) pp 42-46

VOYEVODA, A. A. and STAVROPOL'TSEV, S. A., Novosibirsk Electrotechnical Institute

[Abstract] This study examines the synthesis of regulators for objects which are described by matrix transfer functions with inertial sections, or which can be approximated accurately enough by such matrices. These objects include flight vehicles, technological processes, motors, etc. The problem of choosing the parameters of a multidimensional PI-regulator such that the poles of the system consisting of the regulator and the object are in the required region is studied. The example of synthesizing

a PI-regulator with y-vector feedback for an aircraft turbine is provided.  
References 9: 3 Western, 6 Russian.  
[6-6508]

UDC: 621.317.39:531.78

INFLUENCE OF AXIAL SHAFT LOAD ON OPERATION OF MAGNETOELASTIC TORQUE  
TRANSDUCER

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 8, Aug 83 (manuscript received 4 May 82) pp 27-31

LEVINTOV, S. D. and KOSTYLEV, A. G., Chelyabinsk Polytechnical Institute

[Abstract] Additional transducer errors occur when axial stress is applied to the shaft of a magnetoelastic torque transducer in addition to the stress which is being measured. This study analyzes that additional error and describes confirming experiments. References 5 Russian.

[6-6508]

UDC 621.438.226.3

THERMAL STATE OF COOLED THIN-WALLED NOZZLE BLADE

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian  
No 10, Oct 83 (manuscript received 31 Jan 83) pp 105-107

ARSEN'YEV, L. V., doctor of technical sciences, MITRYAYEV, I. B.,  
candidate of technical sciences, PAVLOV, D. Yu., engineer, POLISHCHUK, V. G.,  
engineer, "Order of Lenin" Leningrad Polytechnic Institute imeni M. I. Kalinin,  
and OSHEROV, Yu. S., candidate of technical sciences, Central Scientific  
Research Institute of Nautical Machinery Building

[Abstract] An experimental study of thin nozzle blades with transverse cooling in gas turbines was made, for the purpose of obtaining data on their thermal state under various operating conditions. Tests were performed with a model blade of 1.2 mm wall thickness and 105 mm chord width, and with four prototype blades placed next to one another with a relative spacing pitch of 0.649 between two side baffles so as to form five passageways (radius of leading edges 10 mm, radius of trailing edges 0.5 mm, entrance angle 90°, exit angle 16°, width of nozzle throat 22.7 mm). Tests were done with a combustion chamber with air-fuel mixing and an air compressor supplying coolant for injection through 6x0.6 mm slots in the blades within their concave part near the exit. The parameters of the propellant gas (combustion products) and of the coolant air were measured, also the temperature of the blade walls with a set of 10 micro-thermocouples, while the Reynolds number was varied from  $6.6 \cdot 10^5$  to  $9 \cdot 10^5$  and the Mach number was varied from 0.6 to 1.0 on the gas side. The gas temperature was varied over the 823-1223 K range and the air entrance temperature was varied over the 400-600 K range, with the relative rate of coolant air varied from 0.7 to 2.7%. The data have been evaluated so as to reveal the temperature distributions over a blade wall and the mean cooling efficiency, the latter correlated with the degree of temperature nonuniformity along a blade. The results indicate that thin blades have better thermal characteristics and are better cooled than thick blades under the same conditions. Figures 3, references 5 Russian.  
[32-2415]

OPTIMIZATION OF COMBINED CONVECTIVE AND FILM COOLING OF PERFORATED BAFFLE BLADES IN GAS TURBINES

Minsk IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: ENERGETIKA in Russian No 10, Oct 83 (manuscript received 16 Dec 82) pp 90-96

BOGOMOLOV, Ye. N., doctor of technical sciences, and ORLOVA, V. I., engineer, Rybinsk Institute of Aviation Technology

[Abstract] Combination convective and film cooling of baffle blades with several rows of perforations in gas turbines is evaluated on the basis of the thermal efficiency of each mode individually and the Kutateladze-Leont'yev relation for the efficiency of a gas shield before an array of perforations. The resultant film effect on a perforated surface is calculated according to the Sellers relation and, for calculating the heat transfer by internal convection, the thermal resistance of the blade wall is assumed to be negligible. The differential equation of coolant flow with continuous transverse jet injection is solved by the numerical method of finite elements. The results indicate ways to optimize the cooling system parameters for given operating conditions. Figures 2, references 4: 3 Russian, 1 Western.

[32-2415]

EXPERIMENTAL STUDY OF HEAT TRANSFER FROM SHAFT IN COOLED RADIAL BEARING OF GNT-25 GAS TURBINE

Moscow TEPLOENERGETIKA in Russian No 4, Apr 83 pp 64-66

RUKHLINSKIY, V. V., candidate of technical sciences, USAYEV, I. D., candidate of technical sciences, and YERMOLENKO, A. V., engineer, Kharkov Polytechnic Institute

[Abstract] The heat transfer from the shaft in a cooled radial bearing of the KhTGP (Kharkov Turbogenerator Manufacturing Plant) design was studied experimentally in a GTN-25 gas turbine. The basic dimensions of the bearing were 315 mm inside diameter and 140 mm width. This split bearing had two oil feed orifices in the plane of separation and its housing was cooled with oil fed through an annular chamber. Heating of the shaft neck and the bearing housing under operating conditions was simulated by means of electric heaters. Measurements were made by the calorimetric method, with the shaft speed 1000-3000 rpm, the temperature of the lubricating oil 30-80°C, the temperature of the shaft surface 40-90°C, the oil pressure at the bearing inlet 0.01-0.098 MPa, the total oil flow rate 1.6-5.5 kg/s, the load on the journal 5-60 kN, and the thermal flux from shaft surface to bearing housing 0-1.6 kW. The experimental data have been processed according to methods of

similarity and dimensional analysis, the results yielding semiempirical relations for the temperature and the thermal flux at the rubbing surface during laminar and transitional flow. Relations have also been obtained from these data for the hot-spot temperature and the friction coefficient at the rubbing surface. The former characterizes the cooling system design and performance, the latter characterizes the bearing efficiency and economy. The results confirm that the effect of energy dissipation in the lubricant on the intensity of heat transfer from the shaft depends largely on the size and the shape of the shaft-bearing clearance. The flow characteristic of lubricant in this bearing is better than in a bearing without bypass groove but worse than in a bearing with bypass groove, the effect of a bypass groove and of lateral pockets being generally an improvement of the pumping action with a stronger dependence of the oil flow rate on the shaft speed. Figures 2, references 2 Russian.

[9-2415]

UDC 621.165.621.822

#### SELECTION OF BEARING TYPE FOR LARGE STEAM TURBINES

Moscow TEPLOENERGETIKA in Russian No 4, Apr 83 pp 28-32

OLIMPIYEV, V. I., doctor of technical sciences, SAFONOV, L. P., doctor of technical sciences, FRENKEL', L. D., candidate of technical sciences, and YURCHENKO, I. S., candidate of technical sciences, Scientific-Industrial Association; Central Institute of Boilers and Turbines

[Abstract] The problem of bearing selection for large high-speed steam turbines with flexible shaft is analyzed from the standpoint of performance and reliability assurance. The main criteria are hydrodynamic stability of the lubricant, balance of masses, and adequate damping, necessary for avoiding or suppressing vibrations. Elliptical bearings with boost lubrication and four-shoe or three-shoe segmental bearings are evaluated comparatively on the basis of theoretical considerations and experimental data. It has been established that the performance can be optimized, in terms of minimum power losses and maximum lubricant economy, by feeding the lubricant directly to and from the supporting film, by feeding the lubricant not "by shaft rotation" but through a slot in the upper half, and by eliminating lubricant flow into idle spaces. Segmental bearings are found not to offer any advantages in this respect, elliptical bearings having furthermore better damping characteristics and thus being most suitable for long continuous operation. Figures 4, table 1, references 12: 8 Russian, 4 Western.

[9-2415]

ESTIMATING DEFECTIVENESS BUILDUP DURING SERVICE IN METAL OF WELDED RUNNER IN LOW-PRESSURE CYLINDER OF TURBINE

Moscow TEPLOENERGETIKA in Russian No 10, Oct 83 pp 42-47

LEYZEROVICH, A. Sh., candidate of technical sciences, All-Union Institute of Heat Engineering

[Abstract] Runners in the low-pressure cylinders of K-160-130 steam turbines are of the welded construction and, therefore, must be carefully monitored for defectiveness buildup during operation. Since conventional flaw detection is not practical here, an experimental-theoretical program has been developed for this purpose. The state of thermal stress of these runners is characterized and determined principally by the temperature difference along the radius of the diaphragm seal in the second stage, approximately proportional to the starting tensile thermal stress along the shaft in the first stage. The problem of estimating the thermally stressed state is solved by the temperature-field plotting method and with the aid of temperature-difference nomograms for startup after down time of various lengths. Convective heat transfer is considered, its effect on the thermal state of the runner being strong at lower temperatures and weak or almost none at higher temperatures. Heat calculations are based on Biot and Fourier numbers, fracture calculations are based on the Pierce formula for crack formation and propagation. Calculations for 34KhMA steel reveal the conditions for brittle fracture and indicate ways to avoid them. Preheating the runner seals with steam under some devacuumization for 2 hours before soft (with respect to temperature rise) startup is recommended as the most effective countermeasure. Figures 6, references 19: 12 Russian, 7 Western.

[30-2415]

SOME PROBLEMS IN IMPROVING RELIABILITY AND ACCURACY OF REGULATORS WITH HYDRAULIC AMPLIFIERS IN MAIN CHANNEL OF POWER TURBINE

Moscow TEPLOENERGETIKA in Russian No 10, Oct 83 pp 38-42

IVANOV, V. A., doctor of technical sciences, PAKHOMOV, V. A., engineer, and CHERNYAVSKIY, L. I., engineer, Leningrad Polytechnic Institute and Leningrad Metal Plant

[Abstract] Pressure fluctuation is the main problem in operation of hydraulic amplifiers with slide valves in the main channel of a steam power turbine, these amplifiers being part of the automatic turbine regulator system and being controlled by flow in the main turbine channel. Such an amplifier can operate with fluid discharge through throttle orifices "behind" or "under" the slider, its other basic components including a pressure

transducer, a controller, and a balancing washer. Experimental studies and theoretical analysis have revealed that the three main sources of pressure fluctuation are: 1) fluctuation of the steam rate behind the inlet diaphragm causing pressure fluctuation with small uniform amplitude along the channel; 2) expansion of the jet behind the inlet diaphragm causing pressure fluctuation with maximum amplitude at some distance along the channel; 3) nonsteady discharge through inlet and outlet diaphragms causing pressure fluctuation with large uniform amplitude along the channel. The performance and the design of slide valves for these hydraulic amplifiers have been evaluated on the basis of this evidence, for the purpose of improving both reliability and accuracy of the automatic turbine regulator system. Insertion of a straightening mesh between throttle inlet orifices and working surface of the slide valve, for instance, will reduce the amplitude of pressure fluctuation and thus also the amplitude of slider vibration, a possible cause of regulator jitter. Figures 6, references 13 Russian.

[30-2415]

UDC 662.997:537.22(088.8)

#### PARAMETERS OF SYMMETRIC RHOMBIC DRIVE MECHANISM FOR SINGLE-CYLINDER STIRLING ENGINE

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 29 Sep 82) pp 29-33

ORUNOV, B., TRUKHOV, V. S., and TURSUNBAYEV, I. A., Physico-Technical Institute imeni S. V. Starodubtsev, UzSSR Academy of Sciences

[Abstract] A symmetric rhombic drive mechanism is used for  $\beta$ -modification Stirling engines in high-efficiency small autonomous power plants. The phase shift between displacing piston and working piston depends largely on the design of the drive components and does largely affect the engine performance in terms of pressure variations during the cycle. A method of calculating the parameters of such a drive has been developed on the basis of the Schmidt model, assuming an ideal gas as the working substance, a 100% efficient regenerator, and isothermal compression and expansion in the hot zone and in the cold zone, without hydraulic power losses in the heat exchanger ducts, leakage or spillage of the working substance. One basic design parameter is the length of the connecting rod. Here calculations are shown for this length as function of the eccentricity and of a power parameter, also for the optimum (with respect to the power parameter) length as function of the eccentricity and of the temperature ratio. It is similarly possible to determine the displacement volume, the piston travel, and the cylinder diameter for required engine performance. Figures 3, references 5: 4 Russian, 1 Western.

[28-2415]

## CHECKING VIBRATIONS OF COILS IN WATER-TURBINE GENERATOR

Moscow ENERGETIK in Russian No 6, Jun 83 pp 32-33

BIRYULEVA, T. B., engineer, NADTOCHIY, V. M., candidate of technical sciences, ORDINYAN, N. A., engineer, All-Union Scientific Research Institute of Electric Power Engineering

[Abstract] Checking the vibrations of generator stator coils was first instituted at the Krasnoyarsk Hydroelectric Power Plant in 1973 and since then in all hydroelectric power plants with larger than 200 MW generators. The inspection procedure involves statistical analysis of data on the vibration parameters and analysis of coil dynamics on the basis of amplitude-frequency characteristics. A preparatory and supporting study of stator coils in 16 generators of 11 different designs has been made by the All-Union Scientific Research Institute of Electric Power Engineering over the 1970-81 period, the stator coils including air-cooled and water-cooled ones with TRI or MKI insulation. Vibrations were measured under conditions of three-phase short-circuit at nominal stator current and 40-120% nominal rotor speed. The basis criterion of vibrational behavior was the maximum amplitude  $2A_{\max}$ , at a 97.5% confidence level, with  $100 \mu\text{m}$  defined as the maximum permissible. The results, presented in tabular and graphic form, reveal that transients with aperiodic currents in the stator winding are most dangerous on account of their triggering resonances at the 50 Hz line frequency. They also indicate a need for separate evaluation of steady-state and transient behavior as basis of an overall diagnosis. The complexity of the problem calls for further study of inspection procedures and evaluation methods. Figure 1, table 1.

[11-2415]

UDC 621.648.4

## DESIGN OF PIPING FOR OIL DRAIN FROM TURBINE BEARINGS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 6, Jun 83 pp 15-17

TOKAR', I. Ya., doctor of technical sciences, professor, ZARETSKIY, Ye. I., candidate of technical sciences, MEL'NIKOV, I. I., engineer, and POLISHCHUK, S. M., engineer

[Abstract] The performance of the piping system for oil drain from turbine bearings is analyzed on the basis of the two-dimensional Laplace equation for flow of a viscous incompressible fluid through a rectangular channel and the Poisson equation for flow of such a fluid into the collector pan. The flow is assumed to be two-dimensional and laminar, stable throughout its path, with negligible inertia forces and negligible pressure variations at the oil-air interface. The solution to this system of equations for the appropriate boundary conditions and experimental data on the oil level along a model drain channel are correlated with the Chezy equation, its coefficient

being most accurately (within 30%) described by the A. D. Al'tshul' relation  $C = 2.66Re^{0.47}$ . An empirical design equation is subsequently derived for the discharge coefficient as function of the Reynolds number in the  $\mu(N_R) = a - bRe + cRe^2 - dRe^3$  form which approximates the results of measurements within 5% accuracy. Figures 6, table 1, references 2 Russian. [16-2415]

UDC 621.313.322-81.001.2

## STABILITY OF TURBINE RUNNERS IN SLIDING BEARINGS UNDER EXTERNAL CIRCULATION FORCES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 6, Jun 83 pp 13-15

AGAFONOV, V. A., candidate of technical sciences

[Abstract] The dynamic stability of turbine runners in sliding bearings is analyzed, taking into account not only the action of hydrodynamic forces in the lubricant film and gas-dynamic forces produced by nonuniform spillage of steam from the high-pressure stage but also the effects of lower runner stiffness, higher steam rate, higher initial steam temperature and pressure, and higher sliding velocity in bearings in turbine sets of higher power ratings. The analysis is based on a system of two differential equations of motion for a shaft carrying a disk at midspan and two algebraic equations of force balance, all equations being two-dimensional in a Cartesian system of coordinates. The corresponding characteristic equation for small deviations from the equilibrium position is formulated as a complete sixth-degree polynomial in the ratio of vibration frequency to shaft speed, with coefficients which include stiffness and damping as functions of the Reynolds number and also the radial bearing clearance. This equation is reduced to a function of a complex variable and solved by the method of D-partitions. Numerical results obtained on a computer for two types of cylindrical bearings, conventional ones and special ones having a bore surface asymmetric with respect to the shaft axis, reveal the circulation forces alone are necessary but not sufficient for self-excitation of runner vibrations. This can occur only when the work of non-conservative circulation forces exceeds the work of dissipative forces, which is likely to happen as the circulation forces increase proportionally to the shaft deflection with increasing runner speed. The results reveal also a continuous shifting of the stability limit and indicate the acceptable range of critical design parameters. Figure 1, references 8: 7 Russian, 1 Western. [16-2415]

CONSTRUCTION OF PROFILES OF INTERMEDIATE BLADE SECTIONS FROM MASTER PROFILES  
GIVEN ON CONICAL SURFACES

Moscow ENERGOMASHINOSTROYENIYE in Russian No 4, Apr 83 pp 6-7

KAPLAN, M. P., candidate of technical sciences, and KOVALENKO, N. N.,  
engineer

[Abstract] An expedient way to produce highly economical turbine stages with wide opening angles is to design them with conical surfaces bounding the flow channel. Here a method is proposed for drawing the profiles of intermediate blade sections on a blueprint from master profiles given on conical surfaces approximating the surfaces of meridional traces of stream lines, after these surfaces have been developed onto a plane. The algorithm of this construction has been programmed for an M-222 digital computer. High design precision requires at least 50 points each on the convex part and on the concave part of the blade contour, and an array of section profiles so dense that the distance between adjacent sections to be drawn does not exceed 30-40% of the chord length. Figures 2, references 11: 10 Russian, 1 Western.  
[14-2415]

CAUSES AND MEANS OF PREVENTION OF EROSION OF EXIT EDGES OF DRIVE VANES IN  
FINAL STAGES OF K-300-240 TURBINE

Moscow ENERGETIK in Russian No 9, Oct 83 pp 8-9

ORLIK, V. G., candidate of technical sciences and REZNIK, L. B., engineer,  
Scientific Production Association, Central Turbine and Boiler Institute

[Abstract] The authors' institute, in cooperation with Lenenergoremont and Kirishi GRES, has developed a method, instruments and devices including aerodynamic and moisture trapping probes, boats and measurement containers and has performed model and field studies of the flow of steam and moisture downstream from the last stage of a K-300-240 turbine in the vicinity of the vertical separating rib. The quantity of moisture flowing toward the drive wheel of the last stage over the inner cone of the exhaust tube was measured, and found to decrease with increasing temperature, disappearing at 140°C. When the turbine is loaded, moisture appears on the cone at approximately 60 MW, reaching 60 kg/hr at nominal mode and increasing with decreasing steam superheating temperature, to 80 kg/hr at 60 MW and 365°C. The steam receiving section of the condenser was found to be overloaded, since the cross section of its drains was not designed to receive steam with excess moisture content. Excessive twisting of the steam flow beyond the last stage in the direction of rotation was experimentally determined. At nominal load, a zone of separation with reverse steam flow toward the drive was found in the root cross section. A significant portion of the drop

moisture near the rib had a velocity component in the direction of the drive wheel of the last stage. The quantity of erosion-dangerous moisture downstream from the last stage depends on the temperature difference between turbine exhaust and the machine room in which it is located. Measures were developed to prevent erosion-dangerous moisture in the exhaust section of the blades by eliminating the causes determined. Figure 1.  
[12-6508]

UDC: 621.438.001.24

#### OSCILLATIONS OF GAS TURBINE INSTALLATION ROTORS UNDER OPERATING CONDITIONS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 7, Jul 83 pp 7-10

IGUMENTSEV, Ye. A., engineer

[Abstract] Experimental studies to determine the frequencies and amplitudes of oscillations of rotor bodies when oil vortexes are present indicated that the frequency of the vortex may differ significantly from half the rotating frequency of the rotor, the amplitude exceeding the levels of oscillations at the nominal rotor speed by many times. Problems of rotor-bearing-body dynamics under operating conditions are thus extremely important. A gas turbine rotor can be looked upon as an elastic beam in compliant supports. A mathematical analysis of the problem is presented. The algorithm used allows the vibration status of a gas turbine to be computed under operating conditions for a GT-750-6 turbine, used in major compressor stations along main gas pipelines. References 11: 9 Russian, 2 Western.  
[17-6508]

UDC: 621.438-752

#### STUDY OF DYNAMIC CHARACTERISTICS OF PREFABRICATED GAS TURBINE COMPRESSOR ROTOR

Moscow ENERGOMASHINOSTROYENIYE in Russian No 7, Jul 83 pp 3-7

ORLOV, I. I., candidate of technical sciences, KENSORINOVA, A. F. and TSIGEL'NIK, A. D., engineers

[Abstract] Results are presented from studies of a prefabricated high-speed turbine compressor rotor designed to operate at 6100 to 7100 rpm. The rotor consists of two parts bolted together: a one piece forged turbine and cast compressor sections. Experimental studies were performed on a large scale model of the rotor planned on the basis of the theory of approximate modeling of rotor dynamics. The model rotor was manufactured at the turbo-motor plant with 8 circular slots distributed over the length of the rotor for balancing purposes. The method of calculation of forced oscillations of rotors considering the dynamic properties of the lubricating layer and

bearings was found to allow the standards for permissible residual imbalance of the rotor to be determined in the planning stage. The dynamic properties of the rotor bearings are very significant in determining the desirability of using various types of bearing supports for rotors operating at 6500 to 8500 rpm. Figures 4, references 18: 13 Russian, 5 Western.  
[17-6508]

## NAVIGATION AND GUIDANCE SYSTEMS

UDC 531.383

### DESIGN OF SINGLE-WHEEL GYROCOMPASS WITH CORRECTION

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 5, May 83 (manuscript received 25 May 82) pp 50-53

RYZHKOY, L. M., Kiev Polytechnic Institute

[Abstract] The feasibility of reducing the intercardinal deviation as well as other dynamic errors of a single-wheel gyrocompass with correction is examined, considering that the time constant of the horizontal indicator must not be long in the case of high-frequency azimuthal oscillations. A system of four differential equations of motion with two correcting torques and two time constants is written for a gyrocompass mounted on a rocking base. This system in angular variables is transformed into one in deviations of the angular variables from their values in the position of static equilibrium. The first approximation of this system yields a simple characteristic equation, its second approximation yields a simple expression for the intercardinal deviation. An analysis of the solution and its stability reveals that the time delay in the horizontal indicator can be shortened while a time delay is introduced into the corrective network. A further advantage is that, unlike the time constant of the horizontal indicator, the time constant of the torque correction can be varied during operation of the gyrocompass. Figure 1, references 4 Russian.

[5-2415]

UDC 531.383

### TWO-STAGE GYROCOMPASS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 5, May 83 (manuscript received 8 Jan 82) pp 45-50

SHESTOV, S. A., Moscow Higher Technical School imeni N. E. Bauman

[Abstract] A two-stage gyrocompass has been developed which includes a tachometer with electrical feedback on the platform with the shaft in either vertical or horizontal position. The tachometer is driven by a gear motor which can be made to be self-braking. The tachometer is driven by a gear

motor which can be made to be self-braking. The tachometer output signal is first stored in a capacitor which it charges, then retrieved through discharge of the capacitor and amplified for homing the platform into the meridional plane. A pause is provided in the operating cycle of the capacitor switch, to allow transients in the tachometer to decay between tachometer signal reading and subsequent platform homing. Separation of the two processes in time by way of cyclic operation with the use of a capacitor makes it possible to pin the instant of time at which the platform reaches the meridional plane, and facilitates extraction of the useful tachometer signal from random interference signals. A performance analysis and evaluation of the static error in the geographic system of coordinates, assuming that the platform is pivoted to a base stationary relative to the earth except for random shaking, reveals that such a gyrocompass has no systematic error and is at least as accurate as one with continuous platform homing. Movement of the platform does not depend here on the tachometer orientation and mounting precision, nor on the stability characteristics of other components. Also the possibility of "seizure" has been eliminated. Figure 1, reference 1 Russian.

[5-2415]

UDC 531.396

#### FLIGHT SIMULATION FOR INERTIAL NAVIGATION SYSTEM

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA MEKHANIKA  
in Russian No 4, Jul-Aug 83 (manuscript received 28 Dec 82) pp 95-99

ALEKSANDROV, V. V.

[Abstract] An inertial navigation system consisting of two accelerometers is considered for flight simulation tests. The accelerometers are mounted on a leveled and gyroscopically stabilized platform absolutely free to move along the azimuthal coordinate. The aircraft with a digital computer on board is assumed to move on a sphere concentric with the earth. The control law in matrix form is derived from the equations describing ideal performance of this navigation and to be simulated on the aircraft computer. The inertial force acting on the masses of accelerometer sensors is simulated with the force of gravity and the dynamic simulation of aircraft flight is aided by another digital computer controlling the test stand. On this basis is then established the feasibility of simulating nonideal performance of the navigation system during perturbations, also the feasibility of flight simulation for a navigation system consisting of three accelerometers and correspondingly operating with six signals: three accelerometer readings and three angles defining the aircraft orientation. Figures 2, references 4 Russian.

[36-2415]

## SELECTION OF OPTIMUM CORRECTING TORQUE FOR VERTICAL GYRO ACCORDING TO SPECIAL-PURPOSE PROGRAM

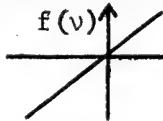
Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 7, Jul 83 (manuscript received 17 Jan 83) pp 50-53

KUBENSKIY, A. A., SERGEYEV, M. A. [deceased] and YABLONSKAYA, V. A.,  
Leningrad Institute of Precision Mechanics and Optics

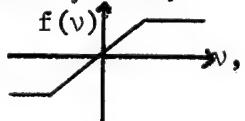
[Abstract] Three modes of correction are considered for a vertical gyro whose rotation relative to the inner gimbal axis can be described by the differential equation

$$H\ddot{\alpha} + f[\ddot{\alpha} + \frac{1}{g}(L_1\ddot{\phi} - L_n\ddot{\gamma})] = M_{fr} \text{ sign.} \quad (H = \text{angular momentum of gyro, } \alpha = \text{angle of gyro rotation; } L_1, L_n = \text{distances from pivot point of gyro to center of mass of object along its longitudinal axis and along its normal axis respectively; } M_{fr} = \text{dry friction torque with respect to inner gimbal axis; } \phi = \text{yaw angle, } \theta = \text{pitch angle, } \gamma = \text{roll angle, all three angles regarded as random functions of time with zero mathematical expectations and with correlation functions of the damped oscillatory kind).}$$

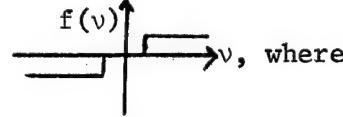
Linear correction is



$v$ , mixed correction is



relay correction with insensitivity zone is



$v$ , where

$f(v) = f[\ddot{\alpha} + \frac{1}{g}(L_1\ddot{\phi} - L_n\ddot{\gamma})]$ . Optimization of the correcting torque in each mode involves linearization of the problem and then finding the slope of the torque-angle characteristic which will yield the minimum mean-square error. The algorithm and calculations have been programmed in FORTRAN. Figures 3, references 3 Russian.

[4-2415]

## PRECISE MOUNTING OF INSTRUMENTS IN UNIVERSAL SUSPENSION WITH SKEWED AXES

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 7, Jul 83 (manuscript received 4 Jan 83) pp 47-50

PERKOV, N. F., Saratov Polytechnic Institute

[Abstract] The problem of resolving the vector of finite rotation into three components along three mutually nonorthogonal axes is solved with the aid of

4x4 quaternion matrices of Rodrigues-Hamilton parameters. The exact solution to this problem is applicable to such practical precision problems as homing an antenna to a target, mounting an instrument on a movable platform, and determining the orientation of an object from readings of a gyroscope set with imprecise initial reading or with skewed gimbals. Figure 1, references 5 Russian.

[4-2415]

UDC 621.3.078

#### SYNTHESIS OF HYPERSTABLE CONTROL SYSTEM WITH ADAPTIVE MODEL

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 7, Jul 83 (manuscript received 19 Oct 82) pp 30-33

CHKHARTISHVILI, G. S. and BEREZIN, V. B., Moscow Institute of Power Engineering

[Abstract] Adaptive systems for control of continuous dynamic objects can be synthesized by using the inverse of the object as model and connecting it in series with the object. The parameters of this model can be tuned adaptively according to the hyperstability criterion. Here the algorithm of adaptation is constructed for a linear dynamic object with one input and one output. The object is described by the differential equation  $\alpha(p)x(t) = (b(p)y(t))$ , where  $y(t)$  is the input signal,  $x(t)$  is the output signal,

$$\alpha(p) = \sum_{i=0}^n \alpha_i p^i \text{ and } b(p) =$$

$\sum_{j=0}^m b_j p^j$  are linear differential operators with constant coefficients  $\alpha_i$  and  $b_j$ ,

$p = d/dt$ ,  $n \geq m$ . The model is described by the differential equation

$b^M(p, t)y(t) = \alpha^M(p, t)u(t)$ , where  $\alpha_i^M(t)$  and  $b_j^M(t)$  are the tunable parameters,

$u(t)$  is the control input signal,  $y(t)$  is the output signal. Digital simulation of such an adaptive control system is demonstrated on a typical second-order object  $(p^2 + 1.5p + 2.5)x(t) = (p + 2)y(t)$ . The method is also applicable to adaptive control of nonsteady and nonlinear objects. Figures 2, references 7: 5 Russian, 2 Western.

[4-2415]

HIGH-ENERGY DEVICES, OPTICS AND PHOTOGRAPHY

UDC: 778.533

POSITIONING ERRORS OF COMMUTATING LENSES AND THEIR INFLUENCE ON CHARACTERISTICS OF HIGH SPEED MOVIE CAMERAS

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE in Russian Vol 25, No 7, Jul 83 (manuscript received 8 Feb 83) pp 83-89

[Article by A. V. Nikulin, S. G. Okishev, and A. A. Tsukanov, Leningrad Institute of Precision Mechanics and Optics]

[Text] This study examines positioning errors of commutating lenses in high speed movie cameras with optical-mechanical image switching. The influence of these errors on the frame exposure rate, the lens speed and other movie camera characteristics is demonstrated.

In high speed movie cameras employing optical-mechanical image switching, the commutating lenses are arranged in a circle with the same distance between their optical axes. During the photography process, as the scanning mirror rotates the image of the aperture diaphragm of the optical system of the movie camera moves across the entrance pupils of the commutating lenses, each of which, when aligned, allows the image to fall on the stationary film in one of the frames. The number of frames obtained is equal to the number of commutating lenses, and is found from the formula [1]

$$P = \frac{\phi_p r k}{b_2 q},$$

where  $\phi_p$  is the working angle of the device within which the scanning is done, radians, which depends upon the construction;  $r$  - distance from reflecting surface of mirror to light sensitive layer, called the optical scanning radius of the camera;  $k$  - number of rows of images on the film, equal to the number of rows in the commutating lens unit;  $b_2$  - film frame dimension in scanning direction;  $q$  - a coefficient indicating the degree of utilization of the film along its length in the scanning direction.

Instability in the positioning of the frames of film determines both longitudinal and transverse frame instability. The study [2] analyzes frame instability in high speed image-switching cameras and the errors that cause this instability. Frame instability in image-switching movie cameras is influenced strongly by errors in the positioning of the commutating objectives. The accuracy with which the frames are placed on the film depends upon the accuracy with which the commutating lenses are arranged around the rim. The accuracy of measurements on movie film, in turn, depends significantly upon the correct positioning of the commutating lenses. Frame positioning errors on the film can be eliminated when copying the film on a duplicating machine [3].

We shall examine positioning errors of commutating objectives and determine their influence on irregular photography speed, relative aperture, aperture ratio, image elimination and frame exposure time in high speed movie cameras employing optical-mechanical image switching.

Figure 1 shows a schematic diagram of the movie camera employing optical-mechanical image switching. The image of the photographed object is formed by entrance lens 1 and component 2 on rotating mirror 3, which, while rotating, rotates the image produced by the mirror so that it will be perpendicular at any moment to the main beam reflected by the mirror, which is an extension of the optical axis of the lens. Each of commutating lenses 4, which are located between scanning mirror 3 and film 5, forms an image of the object on the light sensitive layer of the film at a particular moment.

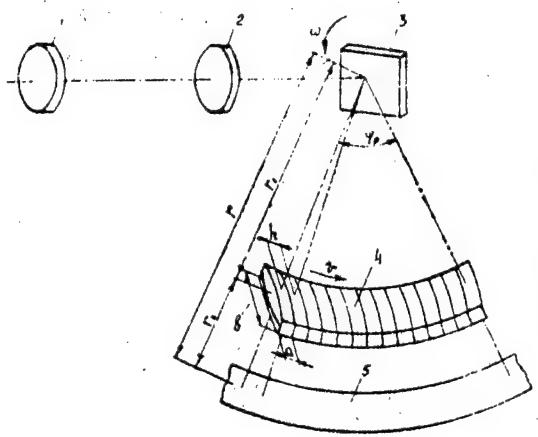


Figure 1.

The commutating lenses are made rectangular with their edges cut symmetrically with respect to the optical axis. This increases the overall relative aperture of the camera. In setting the commutating lenses in the camera, it is possible for errors to occur in the spacing between their optical axes, as well as offsetting across the width of the rim and tilting of their lines of symmetry.

Error in the spacing between the optical axes of the commutating lenses in the scanned direction has an effect on the uniformity of the exposure rate. The exposure rate for a camera employing optical-mechanical image switching is found from the formula

$$v = \frac{v}{h},$$

where  $v$  is the linear velocity of movement of the image of the aperture diaphragm of the optical system of the camera along the entrance pupils of the commutating lenses (cf. figure 1);  $h$  is the spacing between the optical axes of the commutating lenses.

The maximum relative exposure rate can be selected as follows:

$$\left| \frac{\Delta v}{v} \right| = \left| \frac{\Delta v}{v} \right| + \left| \frac{\Delta h}{h} \right|. \quad (1)$$

It follows from expression (1) that the uniformity of the exposure rate is influenced by variation in the rate at which the image of the aperture diaphragm of the optical system of the movie camera moves along the entrance pupils of the commutating lenses  $\Delta v$ , and the error in the spacing  $\Delta h$  between optical axes of the lenses.

Offsetting of the commutating lenses along the width of the rim changes the relative positioning of the entrance pupils of the lenses and the edge of the aperture diaphragm of the optical system of the movie camera, which is aligned with it and equal in size and which, in turn, cuts off part of the light beams, consequently reducing the relative aperture and causing a reduction in the aperture ratio of the device.

The relative aperture of the optical system of a movie camera, expressed through the diaphragm number, can be represented as

$$\frac{1}{K} = \frac{D}{f'}$$

where  $K$  is the diaphragm number;  $D$  is the diameter of the entrance pupil of the optical system of the camera;  $f'$  is the rear focal length of the optical system of the camera.

It can be shown through simple transformations that the expression for the relative aperture for movie cameras with rectangular commutating lenses reduces to the form [1]

$$\frac{D}{f'} = \frac{d_{np}}{r_2},$$

where  $d_{pr} = 2\sqrt{\frac{ab}{\pi}}$  is the diameter of the circle equal in area to a rectangle with sides  $a$  and  $b$  (cf figure 1);  $a$  - transverse dimension of commutating lens in scanned direction;  $b$  - dimension of commutating lens along width of rim;  $r_2$  - distance from commutating lens to film. Since we know

from [4] that the relative aperture of a camera is proportional to the square of the aperture ratio, the relative aperture of the camera is written as

$$\left(\frac{1}{K}\right)^2 = \left(\frac{d_{np}}{r_2}\right)^2 = \frac{4ab}{\pi r_2^2}.$$

Then the maximum relative error in the relative aperture of the camera is written as

$$\left| \frac{\Delta \left(\frac{1}{K}\right)^2}{\left(\frac{1}{K}\right)^2} \right| = \left| \frac{\Delta a}{a} \right| + \left| \frac{\Delta b}{b} \right| + 2 \left| \frac{\Delta r_2}{r_2} \right|. \quad (2)$$

If we know the acceptable relative aperture deviation, we can use expression (2) to determine the tolerance for the offset of the commutating lens across the rim.

Offsetting of the commutating lens across the rim also causes a drop in illumination on the image plane. The illumination in the image plane is determined by the relationship [4]

$$E'_0 = \pi \tau \left(\frac{n'}{n}\right)^2 L \sin^2 \sigma'_{A'}, \quad (3)$$

where  $\tau$  is a coefficient defining the losses in the optical system due to absorption, reflection in scattering, called the throughput factor;  $n'$  - the index of refraction in the image space;  $n$  - the index of refraction in the subject space;  $L$  - brightness of object;  $\sigma'_{A'}$  - aperture angle in image space.

Replacing  $\sin \sigma'_{A'}$ , in formula [3] with  $\tan \sigma'_{A'}$ ,  $\cos \sigma'_{A'}$ , and assuming that  $\tan \sigma'_{A'} = \frac{D'}{2l'}$ , ( $D'$  - diameter of entrance pupil;  $l'$  - distance from exit pupil to image plane), and  $\frac{\pi D'}{4} = S'_{zr}$  ( $S'_{zr}$  - area of exit pupil) we obtain

$$E'_0 = \cos^2 \sigma'_A \cdot \tau \left( \frac{n'}{n} \right)^2 L \frac{S'_{\text{sp}}}{l'^2}.$$

Keeping in mind that the illumination at the picture element at a point removed from the optical axis in relation to the illumination at the center of the image field is determined by the expression [5]

$$E_{\omega'} = E'_0 \cos^4 \omega',$$

where  $2\omega'$  is the angular field of the optical system in the image space; the formula for the illumination of the image for objects of finite dimensions is written as

$$E'_{\text{K}} = \cos^4 \omega' \cos^2 \sigma'_A \cdot \tau \left( \frac{n'}{n} \right)^2 L \frac{S'_{\text{sp}}}{l'^2}. \quad (4)$$

It follows from formula (4) that the illumination in the image plane is directly proportional to the area of the exit pupil and inversely proportional to the square distance from the exit pupil to the image plane.

Assuming that  $n' = n = 1$ ,  $S'_{\text{zr}} = ab$  and  $l' = r_2$ , we use expression (4) to determine the limiting relative image illumination error in the film plane:

$$\left| \frac{\Delta E'_{\text{K}}}{E'_{\text{K}}} \right| = \left| \frac{\Delta b}{b} (1 + 2\sigma'_A \cdot \operatorname{tg} \sigma'_A) \right|.$$

Consequently, lateral shifting of the commutating lens across the rim by the amount  $\Delta b$  causes a drop in the relative aperture of the device and a decrease in the illumination of the image in the plane of the exposed frame.

Figure 2 shows a commutating lens with its line of symmetry tilted through an angle  $\beta$ . Tilting of the commutating lens is interrelated with its offset across the rim by the amount  $\Delta b$ ; therefore, these errors should be examined together.

The image of the aperture diaphragm of the optical system of the camera, shown by the dotted line, moves across the entrance pupil of the commutating lens at the rate  $v$ . Tilting of the lens causes the total exposure time of the photosensitive layer to increase.



Figure 2.

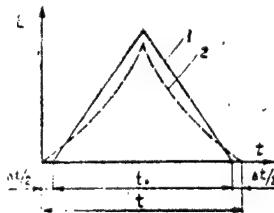


Figure 3.

Figure 3 shows plots of the variation in image illumination as the photosensitive layer is exposed. Curve 1 shows the variation in illumination of the image for commutating lenses installed with no tilt; curve 2 shows the change in illumination of the image for commutating lenses tilted through an angle of  $\beta$ .

The total photosensitive layer exposure time by a commutating lens which is tilted by an angle  $\beta$  and offset by an amount  $\Delta b$  (cf. figure 2) can be found from the expression

$$t = t_0 + \Delta t, \quad (5)$$

where

$$t_0 = \frac{2a}{v} \quad (6)$$

is the total exposure time of the photosensitive layer by a commutating lens positioned without errors;

$$\Delta t = \Delta t_{\text{tilt}} - \Delta t_{\text{off}}, \quad (7)$$

is the total increase in exposure time of the photosensitive layer due to a tilting and offset errors of the commutating lens. The minus sign in formula (7) indicates that offsetting of the tilted commutating lens generally increases the exposure time of the photosensitive layer.

Considering the smallness of the angle  $\beta$ , the increase in exposure time of the photosensitive layer due to tilting of the commutating lens is written as

$$\Delta t_{\text{tilt}} = 2 \frac{S_1}{v} = \frac{b\beta}{v},$$

where  $S_1 = \frac{b\beta}{2}$  is the distance by which the path covered by the image of the aperture diaphragm of the optical system of the camera increases across the entrance pupil of the commutating lens due to tilting.

We represent the reduction in exposure time of the photosensitive layer due to offsetting of the commutating lens as

$$\Delta t_{\text{c}} = \frac{S_2}{v} = \frac{\Delta b \beta}{v},$$

where  $S_2 = \Delta b \beta$  is the amount by which the path covered by the image of the aperture diaphragm of the optical system of the camera decreases along the entrance pupil of a tilted commutating lens due to offsetting.

By substituting the values of  $\Delta t_n$  and  $\Delta t_{\text{sm}}$  in (7), we obtain

$$\Delta t = \frac{\beta(b - \Delta b)}{v}. \quad (8)$$

Then, considering (6) and (8), we rewrite the formula for the total exposure time by a commutating lens tilted by the angle  $\beta$  and offset by the amount  $\Delta b$  as

$$t = \frac{2a + \beta(b - \Delta b)}{v}.$$

Moving on to the minimum relative exposure error due to tilting and offsetting of the commutating objective, we have

$$\left| \frac{\Delta t}{t} \right| = \left| \frac{\beta(b - \Delta b)}{2a + \beta(b - \Delta b)} \right|.$$

Tilting of the commutating lenses and offsetting across the rim thus result in irregularity in the exposure time of the photosensitive layer.

For the VK-12 high speed movie camera [6] developed at LITMO, the limiting relative errors for the maximum positioning errors of the commutating lenses for different interchangeable lens units would be as follows:

$$\left| \frac{\Delta v}{v} \right| = 14,8 + 26,3\%; \quad \left| \frac{\Delta \left( \frac{1}{K} \right)^2}{\left( \frac{1}{K} \right)^2} \right| = 1,8 + 2,1\%;$$

$$\left| \frac{\Delta E'_K}{E'_K} \right| = 1,8 + 2,2\%; \quad \left| \frac{\Delta t}{t} \right| = 6,2 + 10,6\%.$$

These positioning errors of the commutating objectives degrade the characteristics of a high speed movie camera. For this reason, the commutating lenses were placed in the rims in the VK-12 camera on a specially developed device, making it possible to achieve the following results:

$$\left| \frac{\Delta v}{v} \right| = 0,4 \div 0,7\%; \quad \left| \frac{\Delta \left( \frac{1}{K} \right)^2}{\left( \frac{1}{K} \right)^2} \right| = 0,1 \div 0,2\%;$$

$$\left| \frac{\Delta E'_K}{E'_K} \right| = 0,1 \div 0,2\%; \quad \left| \frac{\Delta t}{t} \right| = 0,2 \div 0,3\%.$$

This example shows that when developing high speed movie cameras employing optical-mechanical image switching allowance must be made for the influence of positioning errors of the commutating lenses, appropriate tolerances for the positioning may be assigned, and the commutating lenses must be installed on special devices which ensure the required accuracy in positioning the lenses.

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CSO: 8144/001

UDC 535.231:621.375

OPTOACOUSTIC RECEIVER WITH SEMICONDUCTOR-TYPE RADIATOR AND PHOTODETECTOR

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 9, Sep 83  
(manuscript received 1 Oct 81) p 56

KOLONISTOV, V. P. and ROBACHEVSKIY, M. V.

[Abstract] Conventional optical microphones in OAP-5M optoacoustic receivers use an incandescent lamp as light source and a silicon photodiode as detector. The authors propose to replace the incandescent lamp with an AL-107B GaAs light-emitting diode, its emission line matching the spectral sensitivity of an FD-7K photodiode. This light-emitting diode has a life of 10,000 h, much longer than that of an incandescent lamp, but the intensity of light emitted by it also fluctuates much more. The spectral distribution of these fluctuations is that of flicker noise (1/f). On the basis of comparative signal and noise measurements using the microphone with an incandescent lamp or with a light-emitting diode, also with an overheated light-emitting diode, the microphone sensitivity was adjusted for proper operation with a light-emitting diode without change in the noise-equivalent power. Overheating of the light-emitting diode, which raises the noise level, can be avoided by mounting it on a heat sink and carefully soldering its electrical leads during assembly of the microphone. Figure 1, references 7: 4 Russian, 3 Western.  
[31-2415]

UDC 535.81

MEASUREMENT OF SENSITIVITY OF SHADOWGRAPHIC INSTRUMENTS WITH SPHERICAL AUTOCOLLIMATING MIRROR

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 9, Sep 83  
(manuscript received 10 Dec 82) pp 40-43

AVRAMENKO, A. S., DUROVICH, E. Yu. and NAUMOV, B. V.

[Abstract] In shadowgraphic instruments with spherical autocollimating mirror, which acts as the main objective, the knife is usually placed near

the center of the mirror curvature with the test specimen between knife and mirror surface. Proper use of these instruments requires that their performance parameters such as sensitivity range and sensitivity threshold be known. Conventional sensitivity measurement on the basis of light beam deflection by a long-focus lens or plane-parallel plate as specimen of optical inhomogeneity is difficult and inaccurate on account of inevitable distortions. Another method is proposed that eliminates deflection of the light beam and replaces it with passage of a second light beam through a given point of the test specimen at an angle equal to the would-be deflection angle. The plane-parallel plate now produces a linear shift of diverging light rays equivalent to deflection through an angle proportional to the angle of incidence. The equipment for sensitivity measurement by this method includes an incandescent lamp as light source, a condensing lens, a light-sensitive diaphragm also acting as knife, a projector objective, and a television camera with photosensitive film. Calculations for subsequent data processing are based on laws of geometric optics. Experimental measurements of the sensitivity range were made with a plate of K8 glass, 3.6 mm thick and 32 mm in diameter, before an auto-collimating mirror and at a distance of 495 mm from the optical diaphragm (specific angle 2"/mm corresponding to 60" difference between deflection angles of light rays 30 mm apart). For measurement of the sensitivity threshold, the specific angle was reduced to 1"/mm by using a thinner plate or a plate of a different glass with smaller refractive index, or by immersing the plate in a fluid with similar refractive index. Hardly any alignment of the plate relative to the instrument is necessary. Figures 4, references 5 Russian.

[31-2415]

UDC 681.068:681.75

#### USE OF FOCONS IN COMBINATION WITH BRIGHTNESS AMPLIFIERS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 8, Aug 83  
(manuscript received 20 Apr 82) p 59

BONDAREV, S. P. and KUPREYCHIK, N. P.

[Abstract] The feasibility of combining conical fiber optics as light guide with image converters as amplifiers is examined from both theoretical and practical standpoints. In an experiment the focon was placed in "inverse" position, namely with the narrow end behind the objective projecting an object illuminated through a condenser and with the wide end before the converter window. In such an arrangement the image converter operates in a more favorable mode in terms of image transmission characteristics but with loss of brightness. The tradeoff between improving the image transmission characteristics and worsening the energy characteristics was optimized by selecting a focon with the best ratio of entrance diameter to exit diameter. A focon 65 mm long of a material with a refractive index  $n = 1.51$ , entrance aperture 0.58, entrance diameter 8  $\mu\text{m}$ , exit aperture 0.19, was joined to the

input window of an image converter through a 0.3 mm thick immersion layer. An ORM-31 objective with a 1000/900  $\text{mm}^{-1}$  resolution was used for projecting the image to the focon entrance and a "Kiev-6S" camera with an "Era-15A" objective was used for recording the image from the focon exit on Isopachrom 27" photographic film. With electron-optical gain of 0.7 and 25  $\text{mm}^{-1}$  resolution of the image converter, the system transmitted an optical image with a space frequency of 42  $\text{mm}^{-1}$  and 30% modulation ensuring brightness gain (ratio of image brightness to object brightness) of 20. The maximum theoretical resolution of 75  $\text{mm}^{-1}$  should be attainable through further optimization of focons. Figures 2, references 4 Russian.

[34-2415]

UDC 537.533.34:621.375.826

#### MULTILAYER REFLECTING SYSTEMS BASED ON GLASSY CHALCOGENIDES FOR INFRARED LASERS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 8, Aug 83  
(manuscript received 10 Apr 81) pp 48-52

FIRTSAK, Yu. Yu., DOVGOSHEY, N. I., SHARKOV, V. F., KUROCHKINA, T. N., TARNAY, A. A., and MUCHICHKA, I. I.

[Abstract] Materials of the Ge-As(Sb)-S(Se) system have properties which make them eminently suitable as basis of interference-type reflective coatings on mirrors of infrared power lasers. In addition to having a low absorption coefficient and wide transparency window combined with high radiation resistance, they are insoluble in water (unlike  $\text{CaF}_2$  and other fluorides of alkali-earth metals) and thermally stable (unlike  $\text{PbTe}$  and other tellurides). They also have high mechanical strength and high resistance to cracking in a humid atmosphere (unlike  $\text{ZnS}$ ,  $\text{ZnSe}$ ,  $\text{As}_2\text{S}_3$ ), their refractive indices differing sufficiently for effective color separation by a multi-heterolayer coating. The proper technology and the attainable performance characteristics of interference-type coatings consisting of glassy Ge-As-S, Ge-As-Se, Ge-Sb-Se layers have been established in feasibility studies, continuous and uniform thin layers with specular surfaces having been produced from the raw materials, without significant departure from the original composition, by condensing them on cold substrates ( $\text{NaCl}$ ,  $\text{KBr}$ ,  $\text{CaF}_2$ ,  $\text{ZnSe}$ ,  $\text{Ge}$ ). The vacuum-evaporation process yielded films of 100-300 Å thickness with an absorption coefficient of the order of  $0.1 \text{ cm}^{-1}$  at the  $\lambda = 10.6 \mu\text{m}$  wavelength and with a microhardness within the  $230\text{-}450 \text{ kgf/mm}^2$  range (tensile strength up to  $10^2 \text{ MPa}$ ), their crystallization and breakdown temperatures within  $330\text{-}480^\circ\text{C}$  and  $450\text{-}500^\circ\text{C}$  respectively. The most reliable, chemically stable and optically strong combinations of 2-, 3-, 5-, 7-layer systems were found to be:  
1)  $\text{PbTe}/\text{Ge-As-As}$ ; 2)  $\text{Ge-As-Se}/\text{PbF}_2$ ; 3)  $\text{Ge-Sb-Se}/\text{Ge-As-S}$ . The reflection pattern of a typical 2-layer coating plotted in the  $(0_1, 0_2)$  plane ( $0_{1,2} = 2\pi n_{1,2} d_{1,2} / \lambda$ ,  $n_{1,2}$  - refractive index and geometrical thickness of high-refractivity layer,  $n_{2,2}$  - refractive index and geometrical thickness of

low-refractory layer,  $\lambda$ -wavelength) indicate that on a germanium base the reflection coefficient  $R = f(\varphi_1, \varphi_2)$  of the mirror can be varied from 1 to 86% depending on the coating parameters. The spectral characteristics of such coatings indicate their suitability for CO and CO<sub>2</sub> lasers. With such a coating, for instance, a CO<sub>2</sub>:N<sub>2</sub>:He = 10:45:45 gas-dynamic laser with  $p_0 h \leq 0.5$  atm·cm can deliver an average power of 20 W/g with a 1.2% efficiency at a stagnation temperature of 1700±100 K. Figures 2, tables 2, references 14: 6 Russian, 8 Western.

[34-2415]

UDC 662.997(088.8)

#### DETERMINING OPTIMUM SERVICE CONDITIONS FOR CONCENTRATOR MIRRORS BY METHODS OF MATHEMATICALLY PLANNED EXPERIMENT

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 10 Mar 82) pp 45-49

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USSR Academy of Sciences

[Abstract] A method of mathematically planning an experiment is proposed for determining the optimum service conditions for concentrator mirrors and also obtaining data on mirror performance which can be useful for optimization of the mirror manufacturing technology. First are determined the number of factors influencing a mirror under service conditions and the ranges of their likely variation. Then, by an a priori ranking process and on the basis of preliminary analysis, these factors are classified into significant and insignificant ones in terms of their contribution to the aging process. The method has been applied to aluminum mirrors with front-side reflection and various protective coatings (SiO<sub>2</sub>, SiO<sub>x</sub>, Al<sub>2</sub>O<sub>3</sub>, L-24-7(5) organosilicon varnish), with chemical case hardening (oxidization), or without protection, on glass substrates or on epoxy substrates (in the latter case also with protective mylar film), to aluminum mirrors with back-side reflection and various air- and humidity-resistant varnish-paint coatings, also to water-cooled copper, brass, steel, and nickel mirrors with various protective coatings and interlayers. The plan of a 4-factor (air humidity, abrasive wear by dust and sand, photochemical action of solar radiation, mechanical action of cleaning agent) 3-level (base, upper, lower) experiment is shown and the regression equation is obtained for a typical case. Recommendations on optimum mirror design and selection are made on the basis of this experiment. Figure 1, tables 2, references 5 Russian.

[28-2415]

SOLAR CELLS BASED ON POLYCRYSTALLINE SILICON WITH ISOTYPAL POTENTIAL BARRIERS ALONG GRAIN BOUNDARIES

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 29 Sep 82) pp 13-16

AZIMOV, S. A., AKHMEDOV, F. A., KASYMOVA, T. M., MIRSAIDOVA, Z. and MUMINOV, R. A., Physico-Technical Institute imeni S. V. Starodubtsev, UzSSR Academy of Sciences

[Abstract] Polycrystalline silicon is increasingly used as low-cost material for solar cells, but grain boundaries degrade the performance of such devices. They constitute recombination centers with high density of states, and as such lower the short-circuit current. Those intersecting the plane of the p-n junction also lower the open-circuit voltage and those parallel to that plane constitute additional load resistances. The current-voltage characteristic is steeper, furthermore, because of large leakage currents. A method of reducing this detrimental effect is proposed, its gist being to produce isotypal potential barriers along the grain boundaries. The process involves thermodiffusion of phosphorus at 1000°C for 2 h to produce shallow  $n^+$ -n junctions in the single crystals and strongly doped regions at their boundaries, then chemical etching of the strongly doped  $n^+$ -layer under the surface, and thermodiffusion of boron at 1050°C for 1 h to produce a p-n junction. Experimental specimens of such a solar cell were tested together with a control specimen on plain polycrystalline silicon. Their quantum yield was found to be higher, also peaking within the 2.2-2.5 eV range. They were also found to have a 10-15 mV higher open-circuit voltage, a higher short-circuit current ( $18.5 \text{ mA/cm}^2$  compared with  $14 \text{ mA/cm}^2$ ), and a higher efficiency (above 5.5% compared with 3.9%). Figures 4, references 3 Western.

[28-2415]

PHOTOVOLTAIC CELLS OF InP-CdS HETEROJUNCTION TYPE AND THEIR TEMPERATURE CHARACTERISTICS UNDER A-M ILLUMINATION

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 27 Oct 82) pp 10-13

GORCHAK, L. V., GILAN, E. V., DOROSHENKO, V. G., KITOROAGA, A. D., KOKHANYUK, M. B., RUSSU, Ye. V. and KHANOVA, Ye. S., All-Union Scientific Research, Design Engineering and Technological Institute of Current Sources, Kishinev

[Abstract] The temperature characteristics of photovoltaic cells on InP-CdS heterojunctions with  $p^+$ -p- $n^+$  structure were measured, for a comparative evaluation relative to conventional silicon cells with  $n^+$ -p structure.

Specimens were built on polished p-InP single crystals with (III)-A orientation as substrate wafers (hole concentration  $p = 10^{18} \text{ cm}^{-3}$ , hole mobility  $\mu_p = 65-70 \text{ cm}^2 \text{V}^{-1} \text{s}^{-1}$ , resistivity  $\rho = 10^{-2} \text{ ohm} \cdot \text{cm}$ ). Weakly doped InP layers 4-6  $\mu\text{m}$  thick ( $p = 10^{16}-3 \cdot 10^{16} \text{ cm}^{-3}$ ,  $\mu_p = 140-150 \text{ cm}^2 \text{V}^{-1} \text{s}^{-1}$ ,  $\rho = 0.4-0.6 \text{ ohm} \cdot \text{cm}$ ) were grown epitaxially from the gas phase in the In-PCl<sub>3</sub>-H<sub>2</sub> system and n-CdS films were deposited on them in a closed pool. The specimens were then illuminated with a "Spektr-r" sun simulator containing two 500 W halide vapor lamps and two parabolocylindrical reflectors, the spectral composition of light corrected by means of filters so as to correspond, within 5%, to A-M illumination of the active surface. The measured current-voltage characteristics under luminous flux and temperature dependence of short-circuit current, open-circuit voltage, maximum power, and efficiency over the 185-365 K range indicate a performance not worse than that of silicon devices, with higher thermal stability of the efficiency and lower resistance of the doped layer. This makes InP-CdS devices eminently suitable as a lower-cost replacement of silicon devices. Noteworthy is the occasionally N-shaped temperature characteristic of the short-circuit current. Figures 2, references 8: 4 Russian, 4 Western.

[28-2415]

UDC 662.997

#### SOLAR CELLS WITH DISTRIBUTED PARAMETERS: CURRENT-VOLTAGE CHARACTERISTICS UNDER UNIFORM AND NONUNIFORM ILLUMINATION

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 2 Jun 82) pp 6-10

ARIPOV, Kh. K. and RUMYANTSEV, V. D., Physico-Technical Institute imeni A. F. Ioffe

[Abstract] A simple method of calculating the current-voltage characteristics of solar cells, based on an equivalent resistance-diode ladder network with stripline contacts, is applied to such cells with uniform thickness and various shapes of the active surface. Distributed resistance are represented by equivalent lumped ones. This procedure is applied first to the case of uniform illumination, using measured current-voltage characteristics of cells and very precisely piecewise-linearly approximated exponential current-voltage characteristics of diodes. In the case of nonuniform illumination the latter is assumed to be axisymmetric, with the surface consisting of completely dark and uniformly bright segments. Numerical data have been generated on this basis for GaAs cells of rectangular or sectoral shape uniformly illuminated and in the shape of circular disks either completely uniformly illuminated or with various configurations of concentric dark and bright zones. Nonuniform illumination is found to result in a flatter current-voltage characteristic with a lower open-circuit voltage. Figures 4, references 7: 3 Russian, 4 Western.

[28-2415]

DEPENDENCE OF PARAMETERS OF SILICON PHOTOVOLTAIC CELLS ON TEMPERATURE AND LIGHT INTENSITY

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 12 Aug 82) pp 3-6

BORISOV, S. N., GORODETSKIY, S. M., GRIGOR'YEVA, G. M., ZVYAGINA, K. N. and KASYMAKHUNOVA, A. M., "Order of Labor's Red Banner" All-Union Scientific Research Institute of Current Sources

[Abstract] An experimental study was made of two translucent photovoltaic cells with  $n^+ - p - p^+$  structure and shallow embedded 0.4-0.5  $\mu\text{m}$  thick n-p junction. One device with a 20x24 mm active surface area was built on p-type silicon with resistivity of 1  $\text{ohm}\cdot\text{cm}$ , one device with a 10x21 mm active surface area was built on p-type silicon with resistivity of 28  $\text{ohm}\cdot\text{cm}$ . Their performance parameters were measured over the 0.03-2.5  $\text{W/cm}^2$  range of incident light intensity at temperatures from -140 to +90°C. The measuring equipment included a DKsSh-100 ON xenon-arc lamp as light source with automatic intensity control for holding it within  $\pm 0.5\%$  at each level, a spherical interference-type concentrator, a counterreflector, a main light meter and a control light meter, both cooled, and a water cell as light filter. The light intensity was determined from photometric measurement of a light spot, with an IMO-2 instrument head including a calibrated and thermally stabilized diaphragm. The data obtained in this study include current-voltage characteristics at various temperatures and light intensities, and the temperature dependence of open-circuit voltage, short-circuit current, maximum power, optimum operating voltage and current, and maximum efficiency. The temperature dependence of all these parameters is linear or nearly linear over the given range: the current increasing slightly, the voltage as well as the power and the efficiency decreasing appreciably with rising temperature. Noteworthy is the absence of power peaking in the low-temperature range. Most data are essentially consistent with published data on silicon photovoltaic cells.

Figures 3, references 8: 6 Russian, 2 Western.

[28-2415]

LASER BEAM SHAPING SYSTEM WITH REDUCED OBJECTIVE DIAMETER

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
(manuscript received 5 Jan 81) p 62

SKOBLO, E. Ye., KULIKOVSKAYA, N. I., RYBALKO, I. O., and OVCHINNIKOVA, D. A.

[Abstract] The divergence of laser beams is usually decreased by means of beam shaping galilean telescope optics, keplerian telescope optics not being suitable for this purpose because of resulting excessively high energy concentrations. The use of a galilean system alone requires an appreciable

enlargement of the objective diameter. This enlargement can be reduced by a modification, namely insertion of a converging lens with a focal length  $f_c \geq d_L/2\gamma_L$  ( $d_L$  - exit diameter of laser beam,  $2\gamma_L$  - exit angle of laser beam) between the laser exit window and the ocular. The exact location of this lens is determined by the system geometry and dimensions as well as the maximum allowable energy concentration at optical surfaces, considering that the ocular diameter should be the smallest possible. The proposed method allows much design flexibility. Figure 1, references 5 Russian.  
[2-2415]

UDC 621.373.826

#### SPHERICITY GAUGE FOR WAVEFRONT OF LASER RADIATION

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
(manuscript received 29 Mar 82) pp 58-59

ANDRONOV, V. P., DMITRIYEV, Ye. I. and SHESTAKOV, A. P.

[Abstract] A wavefront sphericity gauge has been developed, built, and tested for use in laser wavefront compensation systems. It detects and measures the longitudinal error of focusing by the lens in such a system due to deviation of the laser radiation wavefront from its required degree of sphericity. The algorithm of detection and measurement involves comparing the radiation intensities in two planes spaced symmetrically with respect to the focusing plane. This algorithm is executed by a radially slotted disk which has been split diametrically into two halves and the latter separated along the axis. The discrimination characteristic of this instrument deviates from a linear one slightly more than theoretically, because of higher-order aberrations, but its sensitivity threshold is not worse than  $0.4 \cdot 10^{-3} \text{ m}^{-1}$  or  $\lambda/12$  in the riser. The authors thank V. Ye. Sherstobitov for interest and helpful discussions. Figures 2, references 2; 1 Russian, 1 Western.  
[2-2415]

UDC 535.346.1

#### SCHEME FOR MEASURING SPECULAR REFLECTION COEFFICIENT AT $10.6 \mu\text{m}$ WAVELENGTH WITH ZIGZAG-PATH CELL AND INTEGRATING SPHERE

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
(manuscript received 6 Jul 82) pp 31-32

ZHEVLAKOVA, T. A. and SEMENTSOV, S. S.

[Abstract] Most accurate measurement of a specular reflection coefficient near unity with an error not larger than 0.1% is possible by the method of

multiple reflections along a cell formed by two mirrors. This method, which averages the reflection coefficient over the surface of the test mirror, can be improved by addition of an integrating sphere in the receiver channel. This principle has been applied to measurement of the specular reflection coefficient in the infrared range. An integrating sphere with sufficiently diffusing surface and nonselective reflectivity is made of pure aluminum, which also features high thermal conductivity and corrosion resistance. A continuous-wave CO<sub>2</sub> laser serves as radiation source, the radiation is modulated at a frequency of 21.5 Hz and the light beam passes through a diaphragm before entering a zigzag cell formed by two parallel mirrors: the test mirror and a reference mirror. The sphere carries a pyroelectric probe with amplifier in its window. One mirror and the sphere can be moved in a plane perpendicular to the light beam so that the latter will enter the sphere either after passing through the cell or directly. Alignment is done with a beam from an He-Ne laser fed into the system by means of two plane mirrors. Random errors of measurement caused by instability of the radiation in time are reduced by moving the sphere from one position to the other so fast that a measurement can be made within 20 s. The spread of values of the reflection coefficient  $R_{\max} - R_{\min}$  obtained by this method has been narrowed from  $\pm 0.03$  without the sphere to  $\pm 0.004$  with it. Figures 2, references 5: 3 Russian, 2 Western.

[2-2415]

UDC 681.7.064.453:681.7

#### COLOR-SELECTIVE COATING FOR VIEWFINDER IN OPTICAL INSTRUMENTS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
(manuscript received 19 Feb 82) pp 28-30

GORELIK, B. D., YEFREMOV, D. Ye. and LAVRISHCHEV, A. P.

[Abstract] A color-selective coating for the viewfinder in optical instruments is described which maintains a neutral coloration of light at any reflection-to-transmission ratio within the desirable R:T = 1-1.35 range. Unlike conventional color-selective coatings consisting of 3, 5, 7, or 9 quarter-wavelength layers, this coating consists of two 3-layer stacks with a separating interlayer built up on a substrate. The interlayer facilitates interference so that light neutralization will be ensured if within each of the seven principal wavelength (color) ranges 720-620 nm (red), 620-592 nm (orange), 592-598 nm (yellow), 578-500 nm (green), 500-464 nm (cyan), 464-445 nm (blue), 446-400 nm (violet) there falls at least one R peak and one T peak, preferably more than one. The maximum number of such peaks is determined from the condition that the distance between successive R and T peaks be of the order of the difference between the wavelengths of monochromatic colors distinguishable by the eye. Maximum and minimum optical thickness of the interlayer are determined from the corresponding conditions of interference and known characteristics of the eye (color resolution 5 nm). Coatings comprising various combinations of MgF<sub>2</sub>, ZnS, ZrO<sub>2</sub>, TiO<sub>2</sub>, CeO, SiO<sub>2</sub> layers have been produced according to

this principle, their spectral characteristics measured, and their performance tested in a mirror-type camera. The wide range of optical thickness of the interlayer contributes to the flexibility of the coating design. Figures 3, table 1, references 2 Russian.

[2-2415]

UDC 621.378.325

#### DEPENDENCE OF PROPERTIES OF OPTICAL CAVITY ON MISALIGNMENT

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
(manuscript received 3 Nov 82) pp 17-18

LEVIT, A. L. and OVCHINNIKOV, V. M.

[Abstract] The effect of misalignment in an optical cavity with plane mirrors and focusing lens on its properties is analyzed in the parallax approximation with the aid of

$\begin{pmatrix} AB \\ CD \end{pmatrix}$  ray matrices, considering that the

principle consequence of misalignment between the resonator components is a change in the length of its optical axis. The resultant ray matrix is obtained as the product of three 4x4 matrices multiplied in the reverse order in which a ray passes through these elements: matrix of translation through distance L (length of the optical axis), matrix of astigmatic lens with principal focal lengths  $f_x, f_y$  and matrix of reflection by a plane mirror. This general method is applied, for illustration, to a ring cavity with an even number of mirrors and aplanar axial contour. Figures 2, references 9: 7 Russian, 2 Western.

[2-2415]

UDC 535.824

#### ABERRATION CHARACTERISTICS OF PLANE-PARALLEL COMPENSATOR PLATE

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
(manuscript received 3 Nov 82) pp 13-16

KOMAROVA, I. E.

[Abstract] A specially constructed plane-parallel compensator plate in a "ring telescope" catadioptric objective does not affect the size of the "dead zone" in the pupil and will not only eliminate parasitic flare or bright spots but also allow the relative aperture of each mirror and of the entire objective to be substantially enlarged. Such a plate consists of two elements, the smaller one with a diameter equal to that of the secondary mirror placed at the center of the larger one so as to face that mirror. Here

the aberration characteristics of this compensator are analyzed according to the laws of geometric optics for wide beams of light rays. Five different compensator configurations are conceived on this basis for complete correction of spherical aberration, with the appropriate formulas given for calculating the necessary plate thickness. Figures 2, table 1, references 3 Russian.  
[2-2415]

UDC 528.517

#### ERROR OF DISTANCE MEASUREMENT BY PHASE-TYPE OPTICAL RANGE FINDERS WITH PHOTORECEIVERS OF VARIOUS TYPES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
(manuscript received 20 Jul 82) pp 3-4

YEGOROV, Yu. P. and PIVOVAROV, B. L.

[Abstract] An optical range finder is considered which consists generally of a radiator, a modulator, a generator of modulating signals, a photoreceiver, a limiter and a phase detector. Assuming that the radiator operates in the continuous mode and that the radiator signal is modulated by a harmonic one, the effect of photoreceiver noise on the error of distance measurement is estimated for two types of photoreceiver: a photomultiplier and a photodiode. For this purpose, the spectral power density of the detector output signal is calculated which will result when an additive mixture of a harmonic modulating signal and photoreceiver noise appears at the detector input. The general expression for this spectral power density is then modified so as to account for the respective noise characteristics of the particular type of photoreceiver, the principal noise in a photomultiplier being flare caused by the incoming radiation signal and thermal noise in the load resistor being the principal noise in the case of a photodiode. The correctness of these relations has been verified experimentally with an optical range finder built according to the general scheme but with a 32DL light-emitting diode as radiator operating in the pulse mode (wavelength 0.84  $\mu$ m, pulse duration 20 ns, pulse power 10 mW, pulse repetition rate 10 MHz). Figures 2, references 3 Russian.  
[2-2415]

FLUID MECHANICS

UDC 621.310.025

ABATEMENT OF NOISE AND VIBRATION IN PIPELINES OF HYDRO SYSTEMS

Kiev ENERGETIKA I ELEKTRIFIKATSIYA in Russian No 1, Jan-Mar 83 pp 19-21

DASHEVSKIY, R. A., candidate of technical sciences, Kharkov Scientific Research Institute of Labor Hygiene and Occupational Diseases, SHCHEV'YEV, Yu. P., candidate of technical sciences, Kharkov branch of Public Design Office, RUDENKO, V. F., candidate of medical sciences, Kiev Scientific Research Institute of Labor Hygiene and Occupational Diseases, and VECHIRKO, V. V., engineer, Kharkov Polytechnic Institute

[Abstract] The mechanism of vibration and the acoustic field in a long water pipeline are analyzed in terms of interaction of forces, propagation of waves, and transfer of energy. Low-frequency and high-frequency vibrations are examined from the standpoint of resulting noise and the possibility of its abatement. Analytical relations for the acoustic impedance of the pipe wall and the damping coefficient in the pipeline transporting a liquid indicate the characteristics of a wall coating necessary for sound-proofing the pipeline. These relations can also be used for redesign of old and design of new low-noise pipelines. References 3 Russian.

[10-2415]

UDC 531.5:533.6.011.32:532.582.33

FLOW AROUND AXISYMMETRIC BODIES WITH UNIFORM-VELOCITY ZONES

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian No 4, Jul-Aug 83 (manuscript received 3 Mar 82) pp 63-67

KOZHUR, L. A., Moscow

[Abstract] The a priori unknown shape of a thick axisymmetric body is determined from the streamlining pattern, on the assumption that such a body with a given volume has a small surface but also a sufficiently high critical Mach number to make nonseparation flow along its surface realizable. The body is furthermore assumed to be symmetric with respect to the  $r = 0$  plane. The velocity is uniform

$v_1$  along the front nose and the back nose and uniform  $v_2$  along the main lateral segment, but not uniform along the spherical transition segments between the main lateral surface segment and the nose segments. The boundary between a spherical transition and the main lateral surface segment is determined from the condition of zero velocity gradient, which in the theory of ideal fluids is equivalent to the Brillouin-Ville "smooth separation" criterion. With the axial lengths of the main lateral segment and of the transition+nose segments known, the problem is formulated as one of calculating the two arcs (angles) characterizing the spherical transition segments, the radii of the main lateral segment and of the nose segments, the radii of the main lateral segment and of the nose segments, and the two velocities  $v_1, v_2$ , and determining the Stokes flow function  $\psi$  which satisfies the corresponding differential equation of potential flow  $\psi_{xx} + \psi_{rr} - \psi_r/r = 0$  with the boundary conditions  $\psi = 0$  along the entire body surface segment, and  $|\nabla\psi|/r = v_1$  along front and back noses,  $|\nabla\psi|/r = v_2$  along the main lateral surface segment, and  $|\nabla\psi|/r \rightarrow r^2/2$  as  $x^2 + r^2 \rightarrow \infty$ . The problem is solved by regarding the body surface as a vortical one with unknown vortex intensity. The solution is obtained by a numerical method, the equivalent of Ryabushinskiy's scheme for axisymmetric jet flow, using a cubic spline with respect to the axial coordinate and subsequent approximating iterations with respect to the radial coordinate for the main lateral segment. In limiting cases the body is a cylinder or a sphere in an unperturbed stream. With the transition segments much shorter than the distance between them, the maximum velocity perturbations are close to the minimum attainable and almost 50% smaller than at an ellipsoid of revolution. Figures 5, references 7: 4 Russian, 3 Western.

[21-2415]

#### SOME OPTIMIZATION PROBLEMS IN STATIC AEROELASTICITY FOR WINGS MADE OF COMPOSITE MATERIALS

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: MEKHANIKA in Russian Vol 36, No 3, Mar 83 (manuscript received 12 Jun 81) pp 21-30

BANICHUK, N. V., Institute of Problems in Mechanics, USSR Academy of Sciences, and IVANOVA, S. Yu., Moscow Institute of Engineering Physics

[Abstract] Two optimization problems are considered which arise in design and construction of straight wings with composite materials. The general object is to minimize the weight of a wing with large aspect ratio under constraints on the critical rate of wing divergence and the critical speed of aileron reversal. The wing is to be made of an elastic isotropic composite material containing randomly oriented reinforcement fibers, the range of fiber concentration being limited by other considerations to  $0 \leq \gamma_{min} \leq \gamma(x) \leq \gamma_{max} \leq 1$ . The equation of aerodynamic equilibrium and the boundary conditions for an elastic wing in a gas stream are used as basis for establishing the optimality criterion and minimizing the weight functional, with the wing treated as a beam. The first problem is to minimize the weight through optimum distribution  $\gamma(x)$  of reinforcing fibers over the wing span for a given critical wing divergence rate. This problem is solved numerically by

the Newton method, and the weight advantage is referred to a wing of the same dimensions with a uniform distribution of reinforcing fibers. The second problem is to minimize the weight through optimum distribution  $\lambda(x)$  of reinforcing fibers over the wing span for a given critical aileron reversal speed. This problem is solved numerically according to the algorithm of successive optimizations, after introduction of the conjugate distribution function and with it the extended Lagrangian weight functional. All calculations are performed in dimensionless variables. Typical results are shown for a carbon-plastic composite with  $\alpha = 8$  and a boron-plastic composite with  $\alpha = 10$  ( $\alpha = E_r/15G_m - 1$ ,  $E_r$  - Young's modulus of the reinforcement material,  $G_m$  - shear modulus of the matrix material). The authors thank V. I. Biryuk, V. V. Kobelev and A. P. Seyranyan for helpful discussions and comments.

Figures 7, references 14: 12 Russian, 2 Western.

[23-2415]

UDC 539.374:534

#### WAVE MOTION OF THREE-COMPONENT MEDIUM UNDER LOAD MOVING ON PLANE BOUNDARY

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 1: MATEMATIKA MEKHANIKA  
in Russian No 4, Jul-Aug 83 (manuscript received 29 Dec 82) pp 100-103

RAKHMATULIN, Kh. A. and DZHASHAKUYEVA, A. K.

[Abstract] The problem of two-dimensional flow induced by a traveling shock wave is solved for a three-component medium such as a mixture of moisture and sand in air. The wave is assumed to travel along the horizontal plane upper boundary of such a medium occupying the entire half-space below. The shock wave is described by a quadratic equation of the  $x = ay + by^2$  kind. Pressure profiles and profiles of longitudinal velocity and normal velocity characterizing the motion of the medium have been calculated by numerical solution of the corresponding Navier-Stokes and Bernoulli equations for the appropriate boundary conditions regarding the pressure and for various angles to the boundary plane at which the wave propagates. Figures 3, table 1, references 4 Russian.

[36-2415]

DEPENDENCE OF VELOCITY DISTRIBUTION IN EXIT SECTION OF CONVERGING CHANNEL ON SHAPE OF INLET CHANNEL IN REGULATING VALVE

Moscow ENERGOMASHINOSTROYENIYE in Russian No 6, Jun 83 pp 12-13

ZARYANKIN, A. Ye., doctor of technical sciences, GOLOVINA, L. G., candidate of technical sciences, and SEREGIN, V. A., engineer

[Abstract] The design of regulating valves for steam turbines, specifically the problem of profiling their inlet channel, is analyzed theoretically from the standpoint of achieving the optimum velocity distribution in the exit section of the converging channel. Limit (maximum-flow) valves with quasi-conical stem are considered, their capacity being 50% higher than that of globe valves under the same pressure head. Smooth acceleration of the vapor stream up to nominal velocity is found to be attainable by replacement of the cylindrical channel segment with a converging one and by thus lengthening the seat. This contributes to a more uniform velocity field in the diffuser entrance section, a higher velocity in the neck, and in maintenance of the required flow rate with the same or even a smaller seating diameter.

Figures 4, references 2 Russian.

[16-2415]

EFFECT OF DRAG BEHIND NOZZLE ARRAY ON ITS FORCE AND ENERGY CHARACTERISTICS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 6, Jun 83, pp 10-11

PYASIK, D. N., candidate of technical sciences, and KOLOMIYETS, M. S., engineer

[Abstract] The effect of drag behind a straight nozzle array of an air turbine on the velocity distribution and thus on the forces and moment at a section of a tilted guide vane was measured with a set of three elastic strain gauges deflecting proportionally to the aerodynamic forces, axial and circumferential, and to the twisting moment respectively. The experiment was performed with an N-4 linear array of 11 uniformly spaced nozzle blades and a cylindrical rod (shaft) with guide vanes movable closer to or farther from that array, at a Mach number  $M = 0.34$  and a Reynolds  $Re = 4.2 \cdot 10^5$  at the nozzle exit. These experimental data and theoretical relations were used to determine the dependence of the axial force, the circumferential force, and the twisting moment on the shaft displacement, the dependence of the distance from the lines of action of both forces to the axis of the vane suspension system on the blading form factor, and the dependence of the integral velocity factor and of the stream exit angle on the form factor. Use of the form factor  $T = yt/\alpha d$  ( $t$ - nozzle blading pitch,  $\alpha$ - minimum cross sectional area of interblade channel,  $d$ - diameter of shaft,  $y$ - distance from

end of shaft to nozzle array) has made it possible to evaluate the effect of the shaft on both force and energy characteristics of the nozzle array, this effect almost vanishing at a form factor  $T \geq 20$ . Figures 5.

[16-2415]

UDC 621.67.000.5

#### EFFECT OF APPARENT FLUID MASSES ON NATURAL VIBRATION FREQUENCIES OF IMPELLERS OF MULTISTAGE CENTRIFUGAL PUMPS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 4, Apr 83 pp 11-13

GROKHOVSKIY, D. V., candidate of technical sciences

[Abstract] Vibrations of the impeller in multistage centrifugal pumps are analyzed, taking into account the effect of apparent fluid masses. Instead of the conventional engineering relations  $\omega^W = (1 + \epsilon)^{-1/2} \omega^a$  and  $\omega_0^W = (1 - \chi) \omega_0^a$  ( $\omega_0^a, \omega_0^W$  - frequencies of free vibrations in air and in water

respectively,  $\epsilon = m_w/m_i$ ,  $m_w$  - mass of water,  $m_i$  - mass of impeller,  $\chi = 0.1-0.16$ ) used for pumps with axial leakage (without seals) and without axial leakage (with seals), the author proposes a more precise relation for pumps with contactless ring seals which is based on design analysis and experimental data:  $\omega_0^W = K_w \omega_0^a$  with  $K_w = (\alpha^4 + \beta)^{1/2} (1 + \sum_{k=1}^3 \epsilon_k)^{-1/2}$ . Here  $\alpha$  accounts

for stiffness of elastic seals and  $\beta$  accounts for hinge constraint on an impeller mounted in two bearings,  $K_w < 1$  signifying that the effect of apparent fluid mass is stronger than the effect of elastic forces in the seals. The range of  $K_w$  is 1.0-2.5 for  $\alpha = 1$  and perfectly coaxial impeller seals. Figure 1, table 1, reference 1 Russian.

[14-2415]

UDC 532,516

#### TURBULENT FLOW AROUND CIRCULAR CYLINDER UNIFORMLY ROTATING IN INFINITE INCOMPRESSIBLE FLUID

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 6, Oct 83  
(manuscript received 11 Mar 83) pp 1322-1326

NOVOZHILOV, V. V., Academician, Leningrad State University imeni A. A. Zhdanov

[Abstract] The problem of flow around a circular cylinder rotating at constant speed is solved for the case of turbulent flow of an incompressible fluid, assuming the fluid medium to be boundless. The fundamental equation follows

from Karman's generalized theory. A qualitatively correct trend indicating solution is obtained for  $n$  ranging from  $2/3$  to  $5/6$  and the Reynolds number  $Re$  correspondingly ranging from  $1 \cdot 10^4$  to  $2 \cdot 10^6$ , without taking into account the curvature of the stream and attendant centrifugal forces. A qualitatively correct solution is then obtained by including the Richardson correction factor for the effect of centrifugal forces on turbulent mixing. A numerical solution has been obtained for  $n = 3/4$ , corresponding to the Blasius range  $5 \cdot 10^3 \leq Re \leq 2 \cdot 10^5$  (for which values of the Richardson correction factor  $F_n(Ri)$  are known). Profiles of the average angular velocity have been plotted on this basis and, for comparison, also on the basis of the fundamental flow equation integrated in quadratures with  $F_n(Ri) = 1$  (no correction). The circulation is evaluated analogously, without and with the Richardson correction. Figure 1, tables 3, references 5; 2 Russian, 3 Western.

[40-2415]

UDC 533.6.011.32

#### STABILITY OF VORTEX STRUCTURES DURING SEPARATION FLOW PAST ARRAY OF WINGS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 6, Oct 83  
(manuscript received 19 Jan 83) pp 1318-1321

KARASK, A. A., LOMOV, S. M. and NISHT, M. I.

[Abstract] The "useful separation" effect, formation of promontory vortices at the front edges of wings, provides useful suction for an aircraft. A study was made concerning the stability of such a vortex structure in an air stream during flow past an array of two thin delta wings with the same small aspect ratio, both wings remaining always in parallel planes as their angle of attack varies and the one ahead simulating a tail. In the theoretical part the problem was analyzed numerically on a computer, with the aspect ratio of both wings varied and their relative position varied widthwise and heightwise. In the experimental part the pattern of vortex formation and collapse at a Mach number  $M \sim 0.3$  and a Reynolds number  $Re = 1.2 \cdot 10^6$  (referred to the chord of the root section of a wing) in a semiopen subsonic wind tunnel with a bilateral Euler chamber was visualized by the shadow method, with an IAB-451 instrument using a cruciform knife edge and a cruciform slit. The results indicate that interaction of vortices at one wing with those at the other tends to improve the stability of both vortex arrays as the angle of attack becomes so large that vortices at one wing alone would become unstable. Both theoretical analysis and physical experiment have provided data on the stability limit for vortices at a single delta wing and at a set of two, namely the maximum angle of attack before collapse of vortices as function of the aspect ratio. Figures 4, references 4 Russian.

[40-2415]

UDC: 621.1.186.1

HYDRAULIC DRAG OF ROD WITH ARTIFICIAL MICROROUGHNESS IN LONGITUDINAL FLOW

Moscow TEPLOENERGETIKA in Russian No 7, Jul 83 pp 46-48

LUL'CHUK, V. L., candidate of physical and mathematical sciences,  
SMIRNOV, V. P., SHUYSKAYA, K. F., candidates of technical sciences,  
SOROKIN, A. G., and TURKIN, A. V., engineers

[Abstract] Results are presented from an experimental study of the hydraulic drag of a rod with artificial microroughness under isothermal conditions under a broad range of flow conditions. The rod was intended to imitate a circular fuel element with regularly alternating spots of microroughness of trapezoidal shape, with each projection 0.1 mm in height, 0.2 mm thick, relative spacing  $S/h = 10$ . The experiments were performed with turbulent flow of air in a circular slot between the tube shell with smooth inner surface and the coaxially inserted rough rod modeling the fuel element. An equation is derived which describes the experimentally hydraulic drag. Figures 2, references 4: 2 Russian, 2 Western.

[18-6508]

UDC: 531.391+532.526+532.592

STABILITY OF STEADY ROTATION OF A CYLINDER FILLED WITH A STRATIFIED VISCOSUS INCOMPRESSIBLE FLUID

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 272, No 5, Sep 83  
(manuscript received 3 Feb 83) pp 1073-1076

DERENDYAYEV, N. V., Scientific Research Institute of Applied Mathematics and Cybernetics of Gorkiy State University imeni N. I. Lobachevskiy

[Abstract] A method is suggested for solution of the planar problem of small scale stability of steady rotation of a cylinder entirely filled with a stratified viscous incompressible fluid. It is assumed that the angular velocity of rotation of the cylinder is maintained constant, and that its axis is in an axisymmetrical viscoelastic attachment. An example is presented of the solution of the problem of stability by the method suggested. It is found that resonant excitation of internal waves in the rotating fluid which fills the cylinder is an important factor in the development of instability. A specific result of investigation of the stability of steady rotation of a cylinder entirely filled with a stratified viscous incompressible fluid is presented, for the case in which the distribution of density has a characteristic spatial scale no less in order of magnitude than the radius of the cylinder. Figures 2, references 6: 4 Russian, 2 Western.

[18-6508]

INFLUENCE OF TURBULENCE OF INCIDENT STREAM ON THREE DIMENSIONAL BOUNDARY LAYER

Moscow TEPLOENERGETIKA in Russian No 7, Jul 83 pp 62-64

BURLAKA, V. V., engineer and GRECHANICHENKO, Yu. V., candidate of technical sciences, Khar'kov Polytechnical Institute

[Abstract] Experimental studies of fuel element arrays have usually been performed with little turbulence of the flow at the inlet, although it is known that under actual conditions turbulence may reach 8 to 12%. This article studies the influence of this turbulence on the boundary layer under conditions approaching actual operating conditions. The possibility is studied of considering the degree of turbulence of the incident stream in theoretical determination of the integral characteristics of the three-dimensional boundary layer using equations averaged across the channel, derived by reducing the three-dimensional boundary layer to a two-dimensional one with three velocity components. The method allows calculation of secondary losses, and indicates that the losses found by the method agree satisfactorily with experimental data. Figures 4, references 5; 4 Russian, 1 Western.  
[8-6508]

## MECHANICS OF SOLIDS

### SOME PROBLEMS IN OPTIMALLY DESIGNING SHELLS OF REVOLUTION

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: MEKHANIKA in Russian Vol 36, No 2, Feb 83 (manuscript received 23 Jun 81) pp 10-17

BANICHUK, N. V., Institute of Problems in Mechanics, USSR Academy of Sciences, and KOBELEV, V. V., Moscow Institute of Engineering Physics

[Abstract] Two problems are considered which arise in design optimization of elastic shells of revolution subject to axisymmetric static loads, specifically shells with a vertically oriented axis. The first problem is to design a shell of minimum mass with strength as the constraint on stresses. This problem is formulated as one to minimize the weight functional and to find the corresponding optimum vertical thickness profile. In this case equistrength shells are found to satisfy the optimality criterion, also when shearing stresses are produced by twisting moments. Considered as examples are a hemispherical bowl and a toroidal bowl subject to hydrostatic pressure by a liquid of given density filling each to the top. The second problem is to design a shell of maximum stiffness. This problem is formulated as one to minimize the displacement functional, for a shell loaded in torsion with the lower horizontal edge constrained and the upper horizontal edge free. It is solved on the basis of the corresponding equation of equilibrium. Again the optimum vertical thickness profile is determined for a fixed shell volume, this time assuming a given vertical profile of the inside radius or assuming that both the thickness and the inside radius are controllable. Figures 7, references 7: 4 Russian, 3 Western.

[22-2415]

UDC 539.3

### REACTION OF PIEZOCERAMIC SHELL TO CONCENTRATED FORCES

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 47, No 3, May-Jun 83 (manuscript received 10 Mar 82) pp 478-482

FIL'SHTINSKIY, L. A. and KHIZHNYAK, L. A., Sumy

[Abstract] The equations of state are formulated for a piezoceramic shell polarized along its generatrix, with two of the three orthogonal coordinate

axes being lines of principal curvatures (the generatrix one of them). These equations relate components of the stress tensor and of the electric induction vector to those of the strain tensor and of the electric field vector, each tensor and vector having three components. The theory of very shallow shells and the Maxwell equations for a dielectric yield a general system of equations in displacements. This system is solved for the case of an array of T-periodic concentrated forces acting on a shell. From the T-periodic fundamental solution is extracted its principal part, whereupon elements of the Green matrix are determined for a shell of finite dimensions. As a specific example is considered a cylindrical shell under a load of radial concentrated forces. Expressions are derived for the asymptotic values of bending moments, shearing forces, and electric potentials in the shell. Numerical results are shown for a typical shell made of PZT-5 piezoceramic material. Figures 3, references 9 Russian.  
[20-2415]

UDC 533:538

#### DYNAMICS OF SOLID BODY WITH ELLIPSOIDAL CAVITY CONTAINING MAGNETIC FLUID

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 47, No 3, May-Jun 83 (manuscript received 28 Oct 82) pp 440-445

BOGOYAVLENSKIY, O. I., Moscow

[Abstract] Motion of a perfectly solid body with an ellipsoidal cavity containing a magnetic fluid is analyzed, assuming that motion of the fluid in the cavity obeys the MHD vector equations with uniform deformation and that normal and tangential components of the electric field and the magnetic field as well as the velocity field are subject to the appropriate boundary conditions at the cavity boundary. Motion of this body is fully described by these MHD equations and the law of conservation of total angular momentum. The problem of dynamics is solved with the classical approach of considering a time interval sufficiently short for the effects of fluid viscosity and of fluid friction against the cavity wall to be negligible. The resolvent system of three equations, obtained after transformation from Lagrange to Euler coordinates, generalizes the classical equations of motion for a body with an ellipsoidal cavity containing an ideal fluid. The most important integral here is that of total energy, the sum of kinetic energy of the fluid + internal energy of the magnetic field + kinetic energy of the body rotation. In the case of zero total angular momentum these equations become analogous to the classical Kirchhoff equations of motion for a solid body with three planes of symmetry in a fluid medium. In this case a two-parametric family of values for the inertia tensor satisfying the Clebsch condition for integrability of the system of dynamics equations is shown to exist for an ellipsoid with any ratio of semiaxes. The results of this analysis are applicable to the dynamics of rotation of astrophysical objects such as neutron stars and pulsars, particularly significant being the solutions which correspond to minimum total energy. The author thanks A. G. Kulikovskiy for discussion of the results. References 9 Russian.

[20-2415]

STABILITY OF STEADY MODES OF MOTION BY AXIS OF ROTATING WHEEL IN NONLINEAR BEARINGS

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 47, No 3, May-Jun 83 (manuscript received 4 Nov 82) pp 378-384

MERKIN, D. R., Leningrad

[Abstract] A perfectly solid wheel with eccentricity is considered rotating on a vertical shaft, the latter mounted in elastically compliant bearings rigidly coupled to a stationary base. The wheel is first assumed to be driven by an ideal (infinite-power) motor and its motion is assumed to be plane-parallel. The stability of its steady-state rotation is analyzed on the basis of corresponding differential equations of motion and their solution, these equations being of the gyroscopic kind so that the first Thomson-Tetche-Chetayev theorem and the condition for gyroscopic stability are applicable. The external drag force is assumed first to be zero and then to be proportional to the shaft speed (constant damping coefficient). Finally, with the same conditions of wheel unbalance and elastic bearing reaction, a nonideal (finite-power) drive motor is considered. In this case the Hurwitz determinant of the characteristic equation yields cylindrical precession and an always unstable second mode of steady-state shaft motion so that only the first mode can exist. The effects of an only finite-power drive are a narrower range of stable precession with zero damping and also a replacement of plain stability with asymptotic stability, at any wheel eccentricity and any reaction force, with any nonlinearity, when the damping coefficient is zero. Accordingly, asymptotic stability of steady-state shaft motion with nonzero damping requires that the wheel eccentricity be smaller than critical and the wheel thus be precisely balanced. Since this is not always feasible, linear elastic bearing retainers will eliminate destabilizing pressure reaction.

Figures 4, references 9 Russian.

[20-2415]

STABILITY OF PERMANENT ROTATION MODES OF ASYMMETRIC HEAVY SOLID BODY

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 47, No 3, May-Jun 83 (manuscript received 20 Jul 82) pp 372-377

ANDREYEV, D. V., Moscow

[Abstract] Rotation of a heavy solid body with one stationary point about a vertical axis not passing through its center of mass is analyzed for stability, its principal moments of inertia with respect to that point being  $A > B > C$ . Three Cartesian systems of coordinates with a common origin at that point are introduced: one stationary with a vertical axis, one whose axes

coincide with the principal axes of inertia, and one rigidly tied to the body with one axis being the permanent axis of the body. After linearization of the system of equations of perturbed motion, the conditions for stability of permanent rotation are established on the basis of the Hamiltonian, first in nonresonant modes with the aid of the Stäude cone, and then in third-order and fourth-order resonance modes. In all nonresonance modes, except perhaps a finite number of them, stability or instability are in this way determined in the first approximation only. Stability or instability of the resonance modes is in this way determined exactly and found to depend only on the distribution of masses in the body. The author thanks V. V. Rumyantsev for his attentiveness. References 14: 12 Russian, 2 Western.

[20-2415]

UDC 621.824.4:539.385.001.24

#### TWISTING OF SEGMENTAL SHAFTS

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 9, Sep 83 pp 26-30

KONOVALOV, L. V., candidate of technical sciences, KUKLEVA, L. N., candidate of technical sciences, SANZHAREVSKIY, A. I., candidate of technical sciences, and VINOGRADOVA, M. D., candidate of technical sciences

[Abstract] Torsional stresses in segmental shafts with compound rather than simple circular cross sections are calculated on the basis of the fundamental Poisson equation for the torsional stress potential and the evolving principle of minimum potential strain energy. The solution has been programmed in ALGOL for a BESM-6 high-speed computer. Numerical data have been obtained by digital simulation for a shaft cross section smaller than a semicircle with a rectangular slot symmetrically cut in the middle of the base (chord). The results yield stress concentration factors needed for design and maximum stresses, the latter occurring at the center of the slot bottom or at the corners depending on the relative slot depth. The results are more accurate than those based on electrical analog simulation. The method and the results can be extended to shafts with arbitrary cross sections, with the aid of experimental verification. Figures 5, tables 3, references 10 Russian.

[41-2415]

UDC: 531.55:521.1

STABILITY OF STEADY MOTIONS OF DYNAMICALLY SYMMETRICAL SOLID AT A  
TRIANGULAR LIBRATION POINT

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 47, No 2,  
Mar-Apr 83 (manuscript received 29 Jan 82) pp 337-340

RUZANOVA, V. N., Moscow

[Abstract] The motion of a dynamically symmetrical solid relative to its center of mass placed at a triangular libration point of the circular limited 3-body problem is analyzed. Two systems of coordinates are used to study the motion of the solid relative to its center of mass: the orbital system and the coupled system. The dimensions of the solid are considered small in comparison with the distance from its center of mass to the location of the two rotating bodies. The problem studied is a natural generalization of the problem of regular precession of a satellite in circular orbit. Figure 1, references 10: 9 Russian, 1 Western.

[19-6508]

UDC: 533.6

APPROXIMATE ANALYTIC METHOD OF CALCULATING TRAJECTORIES OF MOVEMENT OF A  
FLIGHT VEHICLE IN THE ATMOSPHERE

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 47, No 2,  
Mar-Apr 83 (manuscript received 4 Jan 82) pp 348-452

IVANOV, N. M., MARTYNOV, A. I., and SOKOLOV, N. L.

[Abstract] An approximate method is suggested for calculating the trajectory of a flight vehicle in the atmosphere considering loss of mass by the vehicle and rotation of the planet. The effectiveness of the method is demonstrated for calculation of reentry of a vehicle at high velocity. A number of numerical examples are appended. Figures 4, references 15: 6 Russian, 9 Western.

[19-6508]

STABILIZATION OF STEADY MOTION OF MECHANICAL SYSTEMS

Moscow PRIKLADNAYA MATEMATIKA I MEKHANIKA in Russian Vol 47, No 2, Mar-Apr 83 (manuscript received 27 May 82) pp 302-309

KRASINSKAYA, E. M., Tashkent

[Abstract] A study is made of a scleronomous nonholonomic system assuming that forces are applied on both positional and cyclical coordinates. The possibility of stabilizing unstable steady motion by application of forces of a predefined structure to the cyclical and positional coordinates is analyzed. It is assumed that the balancing forces depend on the positional velocities. It is found that application of a force on cyclical coordinates can in certain cases stabilize unstable but steady motion. Motion which is unstable where  $\sin^2\theta_0 < 1/3$  can be stabilized by the application of a force the frequency of which is selected from the condition  $c^*\theta_0 > 0$  plus an arbitrary dissipative force  $Q_\theta = -d_1\theta$ . References 13: 12 Russian, 1 Western, [19-6508]

THERMAL DEFORMATION OF FLEXIBLE ROTORS IN FRICTION BEARINGS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 83 pp 6-9

GOL'DIN, A. S., candidate of technical sciences, L'VOV, M. I. and UR'YEV, A. V., engineers

[Abstract] During balancing of the rotor of the R-100 turbine it was found that significant changes in vibration parameters in the bearings were caused by thermal deformations of the cantilever section. The smooth change in vibration parameters with the passage of time and reversible nature of changes indicate the thermal nature of deformation of the rotor, the location of the imbalance indicating that the deformation occurs primarily in the cantilever section of the rotor. A simplified mathematical model of the rotor is analyzed. The following measures are suggested to reduce the influence of thermal deformation on the process of balancing: maintenance of identical conditions of lubrication, including temperature and flow rate of oil, for all balance runs; repeated runs without changing of balancing masses to evaluate the accuracy of determination of vibration parameters; smooth increases in rotor rotation speed during all balancing runs and measurement of vibration parameters with continuous changing frequency; if necessary, separate balancing of parts of cantilever sections, Figures 6. [15-6508]

## TESTING AND MATERIALS

UDC 681.41:621.357.74:621.753.1/2

### DIMENSIONS OF SMOOTH MATING PARTS WITH PROTECTIVE COATINGS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 9, Sep 83  
(manuscript received 1 Dec 82) pp 37-40

GOBERMAN, P. N., [deceased]

[Abstract] In the optico-mechanical industry it is common to mate parts with protective coatings of different thicknesses. The problem of ensuring the proper fit is essentially a problem of dimensioning. A tolerance field must be established for the dimensions of optical parts before they are coated, taking into account the type of interchangeability. The tolerance field may be a standard one for the industry, a standard one for a given enterprise, or a special one for a given set of parts. The tolerance field must also take into account, probabilistically, what the fit will be after the parts have been coated. The final fit, allowing for clearance or for interference, is calculated according to appropriate formulas, whereupon the feasibility of replacing a special tolerance field with the enterprise standard or even the industry standard is examined. A ball bearing on a coated shaft is a case of outer (bearing) interchangeability, with the shaft dimension serving as reference. A plug in a hole is a case of inner (plug) interchangeability, with the hole dimension serving as reference. The procedure is demonstrated on a typical hole and plug pair with coated mating surfaced. Calculations are performed according to the minmax method. Figures 3, references 2 Russian.

[31-2415]

ROLE OF FLUID LUBRICANT-COOLANT IN FINE GRINDING OF OPTICAL GLASS BY DIAMOND TOOL

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 8, Aug 83  
(manuscript received 23 Aug 82) pp 38-41

AL'TSHULLER, V. M., ASHKEROV, Yu. V. and KOROVKIN, V. P.

[Abstract] A study was made for the purpose of not only correlating the microhardness of large optical surfaces with the performance of a diamond grinding tool but also determining the role of a fluid lubricant-coolant in the fine-grinding process, particularly the dependence of its role on its composition. Blanks of five optical glasses with an initial surface roughness  $R_a = 2 \mu\text{m}$  were ground by "free lapping" with a diamond tool containing 25% size 28/20 grains and 75% M21 metallic bonding, under a load of  $1.9 \text{ kgf/cm}^2$  and a wheel speed of 1100 rpm. The results indicate that the productivity of the grinding process does not depend on the composition of the lubricant-coolant in the case of glasses with low scratch hardness (grades BF16, TF2, STK9) but is very sensitive to its composition in the case of glasses with high scratch hardness (grades LK5, K8). In the latter case a 30% aqueous solution of glycerin is an overall most effective lubricant-coolant, allowing the tool to retain its sharpness for long periods of time but also contributing to its high rate of wear. Plain water is least effective and 1% aqueous solution of triethanol amine or 4% aqueous solution of Dama Co. emulsion are of intermediate and more selective effectiveness, involving a tradeoff between sharpness retention with low tool wear and productivity. The role of a fluid lubricant-coolant is thus determined by changes occurring in the mode of fracture within the glass surface layer as well as by changes in the rate of tool (grains and bonding) wear. There is a direct though intricate relation between scratch characteristics of glasses and their grindability, but no definite correlation with the retention of tool sharpness has been established. Figures 2, references 10: 6 Russian, 4 Western.  
[34-2415]

STRUCTURAL, MORPHOLOGICAL AND OPTICAL CHARACTERISTICS OF KGd(WO<sub>4</sub>)<sub>2</sub> CRYSTALS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 8, Aug 83  
(manuscript received 29 Mar 82) pp 35-36

ANAN'YEVA, G. V., AFANAS'YEV, I. I., VASIL'YEVA, V. I., GLAZOV, A. I., MAMONTOV, I. Ya, and MERKUL'YAYEVA, T. I.

[Abstract] A KGd(WO<sub>4</sub>)<sub>2</sub> crystal, suitable as active laser material with Nd<sup>+3</sup> doping, has a low-order symmetry which makes determination and normalization of its optical characteristics difficult. Its atomic structure is described

by the P/2m group of spatial symmetry. A correspondence between the principal axes and the structure of this biaxial crystal has been established on the basis of x-ray structural analysis with a URS-50IM x-ray diffractometer and a Stoe Co. model F goniometer as well as optical measurements. Based on this study and plotting of the stereographic projection of such a crystal, its lattice parameters and optical indicatrix are found. Its optical orientation can accordingly be described as  $n_g = b$  and  $n_{pc} = 20^\circ$  with the optical axes at an  $86.5^\circ$  angle to one another lying in the plane of the crystallographic b-axis zone. Figures 3, references 4 Russian.

[34-2415]

UDC 662.997:537.22

#### SELECTIVE COATINGS FOR SOLAR-TO-THERMAL ENERGY CONVERTERS

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 4 Mar 82) pp 43-45

GUKHMAN, G. A. and KOLTUN, M. M., State Scientific Research Institute of Power Engineering imeni G. M. Krzhizhanovskiy

[Abstract] Thin porous interference-type selective coatings used on tubular collectors of solar radiation are not suitable for flat collectors. Instead, a selective coating of this type is proposed which consists of a thick  $Al_2O_3$  layer with embedded metal particles and on it an infrared reflecting layer of electrically conducting vitreous ceramic material ( $PbO$  or  $In_2O_3$ ). Both layers are deposited electrochemically on collectors made of aluminum or an aluminum alloy. In the case of collectors made of copper, the surface must be first protected against oxidation and for this a double layer consisting of 2-3  $\mu m$  thick chromium on 9-10  $\mu m$  thick nickel is very effective. Experimental specimens of such coatings were tested in a laboratory humidity chamber and are now tested under the climatic conditions in the Crimea, 750,000  $W \cdot h/m^2$  of solar radiation at a mean-weekly intensity of  $700 W/m^2$  having been accumulated in nine months. Their optical characteristics are excellent: ratio of heat absorbing to total surface area  $A_c > 0.9$  and emissivity  $\epsilon \leq 0.2$ , not degraded by holding in a furnace at  $500^\circ C$  for 50 h. The feasibility of producing multilayer coatings of this type has been established on the basis of computer calculations for various combinations of collector material and protective interlayers. Table 1, references 14: 9 Russian, 5 Western.

[28-2415]

ERROR ANALYSIS OF HELIOSTAT ALIGNMENT METHODS

Tashkent GELIOTEKHNIKA in Russian No 4, Apr 83  
(manuscript received 10 Mar 82) pp 22-26

ZAKHIDOV, R. A., ABDURAKHMANOV, A., KLYCHEV, Sh. I. and BOGDASAROV, V. M.,  
Central Design and Planning Office of Scientific Instrument Building,  
UzSSR Academy of Sciences

[Abstract] There are four basic methods available for alignment of heliostats:  
1) with use of levels; 2) by autocollimation; 3) on basis of superposed  
images; 4) on basis of "broken" images. They all involve placement of a  
reflecting facet surface into a definite position relative to a stationary  
reference plane. The actual alignment operation is preceded by drawing  
normals to the reference plane and to the given facet, respectively, each  
operation being repeated for each facet. The accuracy of each step is limited  
by inevitable systematic errors. Derivation of the total error in each method  
reveals their particular features and preferential ranges of application.

Figures 2, references 4 Russian.

[28-2415]

RESISTANCE OF OPTICAL COATINGS TO ALKALI SOLUTIONS AND SEA WATER

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
(manuscript received 19 May 82) pp 59-61

KUZNETSOV, A. Ya.

[Abstract] The resistance of optical coatings of  $SiO_2$ ,  $TiO_2$ ,  $ZrO_2$ ,  $HfO_2$   
films and their combinations to alkali solutions and to sea water was  
measured in an experimental study with such coatings chemically deposited  
on highly resistant K8 glass as substrate. Specimens initially 120 nm thick  
were soaked in  $NaOH$  solutions with various concentrations from 0.1 N to  
0.9 N at 20°C and at 50°C for up to 60 h. Least resistant was found to be  
 $SiO_2$  and then  $TiO_2$ ,  $ZrO_2$ ,  $HfO_2$  in increasing order. Other specimens initially  
130 nm thick were soaked in sea water containing 3.5 wt.%  $NaCl$  + 0.3 wt.%  
 $MgSO_4$  (simulating Pacific Ocean water with pH 7.6) under the same conditions.  
Scattering of light by  $SiO_2$  coatings began to increase after 30 days at 50°C  
but not till after 50 days at 20°C. The other coatings broke down after  
50 days at 50°C and after 90 days at 20°C, first  $SiO_2$  and then  $TiO_2$ ,  $ZrO_2$ ,  
 $HfO_2$  successively later. Figures 2, tables 2, references 5 Russian.

[2-2415]

TRANSDUCER OF LINEAR DISPLACEMENTS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
(manuscript received 23 Sep 82) pp 35-37

MALAMED, Ye. R.

[Abstract] Several photoelectric high-precision transducers of linear displacements for applications ranging from general-purpose instrument microscopes to multicoordinate measuring instruments have been developed during the past eight years by the Leningrad Optico-Mechanical Association and are successfully operating in industry. The basic PLP transducer is designed for a UIM-29 microscope and a 2-coordinate measuring instrument with electronic digital readout. Its optical system consists of an AL-107B light-emitting diode as light source, two condenser lenses, a special wedge carrying two pairs of joined receiver lenses, a prism-mirror, a photoreceiver, a wedge-shape transparent replica of a twin diffraction grating which prevents light reflected by the air-glass interface from focusing on the receiver photodiodes, and a reflective replica of a diffraction grating on a movable carriage. The already available three models of this transducer are PLP1-0.2, PLP1-0.5, and PLP1-1.0 with respectively 625, 250, 125 lines/mm on the transparent replica and respectively 312.5, 125, 62.5 lines/mm on the reflective replica. The scale of moire-interference fringes characterizing the shift between both diffraction gratings per grating period (9.16 mm in each model) is respectively 0.8, 2.0, 4.0  $\mu\text{m}$  and the angle between the two arrays of grating lines on the transparent replica is respectively  $36\pm 4$ ,  $90\pm 10$ ,  $180\pm 20^\circ$ . Figures 2, table 1, references 4 Russian.

[2-2415]

NONUNIFORM INTERFERENCE COATINGS WITH THICKNESS-DEPENDENT REFRACTIVE INDEX

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
(manuscript received 23 Mar 82) pp 26-28

BOKHONSKAYA, I. F. and KRYLOVA, T. N.

[Abstract] Nonuniform transparent films with a refraction gradient are used as coatings on optical glass for achromatization of interference coatings, particularly for widening the spectral range of low residual reflection where the first layer of such a two-layer coating has a nonuniform refractive index at the film-substrate interface. A computer program has been developed for calculating the reflection spectrum of glass surfaces with such coatings whose refractive index decreases linearly with their thickness down to values close to those of the substrate glass relative to air. These calculations, by the recurrence method, take into account multiple reflections. The results

of calculations for five grades of glass K8, STK3, STK8, TF5, TF10 with the refractive index relative to air  $n = 1.518, 1.659, 1.703, 1.755, 1.806$  respectively reveal that addition of films with a refractive index decreasing to  $1.45 \dots 1.40 \dots 1.35 \dots 1.20$  will decrease the reflection from  $8 \dots 4$  to  $3.2 \dots 2.8 \dots 2.2 \dots 0.8\%$ . Experimental results with  $\text{SiO}_2$ ,  $\text{TiO}_2$  and Teflon 32 films ( $n = 1.45-1.40$ ) on TF5 glass confirm this. No advantage has been gained by using films whose refractive index decreases nonlinearly with their thickness. Figures 3, table 1, references 12: 9 Russian, 3 Western.

[2-2415]

UDC 621.52:539.231

## PECULIARITIES OF $\text{MgF}_2$ FILM FORMATION AND OPTIMIZATION OF $\text{MgF}_2$ FILM DEPOSITION PROCESS

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENOST' in Russian No 7, Jul 83  
(manuscript received 2 Sep 82) pp 24-26

POVESHCHENKO, V. P., KOSTYUCHENKO, N. G., PONKRATOV, V. V., KHOLODOV, V. M., MOZGIN, V. I. and TROFIMOVA, Zh. P.

[Abstract] An experimental study was made of the  $\text{MgF}_2$  film formation process for the purpose of optimizing this process in VU-1S vacuum deposition equipment. Most important was determining the maximum temperature at which subsequent exposure to air would not change the optical properties of these films, also determining the feasibility of shortening the process time. The temperature of the substrate during film deposition under a vacuum of  $1 \cdot 10^{-5}$  mm Hg was varied from 50 to 300°C. Phase analysis of the raw compound and of the product was performed with a "Dron-1" x-ray diffractometer, the parameters of their crystal lattices were calculated within  $\pm 5\%$  accuracy on a YeS-1020 computer according to a special program written in FORTRAN. One set of results reveals that the parameters  $\alpha$  and  $c$  of the tetragonal crystal lattice decrease with increasing deposition temperature,  $\alpha$  decreasing slightly and  $c$  (thus also the ratio  $c/\alpha$ ) decreasing sharply. Another set of results reveals that the refractive index of  $\text{MgF}_2$  films does not depend on the holding time at 300°C. Air exposure of specimens held at temperatures up to 100°C was found to affect neither the phase composition nor the refractive index. Deposition with accelerated heating, without subsequent holding at the deposition temperature, and subsequent cooling to 100°C should shorten the total process time by 50 min and yield films with consistent excellent characteristics. Figures 3, references 9: 6 Russian, 3 Western.

[2-2415]

## WATER-RESISTANCE AND SOME OTHER PROPERTIES OF POLYALKALI FLUOROPHOSPHATE GLASSES

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
 (manuscript received 1 Apr 82) pp 22-23

FEDOROVA, L. V., MOLCHANOV, V. S., URUSOVSKAYA, L. N. and  
 ZVENIGORODSKAYA, A. N.

[Abstract] Water resistance and chemical stability as well as some optical properties of several fluorophosphate glasses with alkali content (57.8 mol.% NaF) were determined experimentally, for the purpose of filling a lack of data on these materials with excellent dispersion characteristics in the ultraviolet region of the spectrum. The base material was glass containing 57.8% NaF + 18.4%  $Al(PO_3)_3$  + 14.0% RF + 5.8%  $B_2O_3$  + 4.0% BaO. Various modifications were derived through addition of LiF,  $MgF_2$ ,  $BaF_2$ ,  $PbF_2$ , SrO, BaO, PbO,  $GeO_2$ ,  $ZrO_2$ ,  $Nb_2O_5$ ,  $Ta_2O_5$ ,  $WO_3$  respectively. Specimens of these glasses were produced in platinum crucibles, first heated and held for 22.5 h at 800°C in an electric furnace, then cast into molds at 400°C, and annealed in a muffle furnace. Optical properties were measured with a 5" goniometer and an IRF-23 refractometer. The density was measured by hydrostatic weighing. The effect of water on the resistance to tainting and dissolution by chemicals was measured by a special method, using a silver vessel with distilled water at 90°C and rotating the immersed specimen for 1 h, weighing the dry specimen before and after that treatment. The results indicate that addition of SrO, BaO, PbO,  $BaF_2$ ,  $PbF_2$  does not affect the water resistance of glass, while every small additions of  $Ta_2O_5$ ,  $ZrO_2$ ,  $WO_3$ ,  $GeO_2$  increase it appreciably. It is noteworthy that  $MgF_2$  has also a beneficial effect on the water resistance and that LiF has no effect even in large amounts. Table 1, references 5: 4 Russian, 1 Western.

[2-2415]

THRESHOLDS OF OPTICAL BREAKDOWN IN ALKALI-HALIDE CRYSTALS UNDER PULSES FROM  $CO_2$ -LASER

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST' in Russian No 7, Jul 83  
 (manuscript received 11 Aug 82) pp 10-13

VOLKOVA, N. V., KRUTYAKOVA, V. P., SMIRNOV, V. N. and TSIRUL'NIK, P. N.

[Abstract] An experimental study was made to determine the thresholds of optical breakdown in NaCl, KCl and KBr crystals under pulses of infrared radiation from a  $CO_2$  laser, such crystals being widely used in laser equipment and wide discrepancies being found in theoretical as well as experimental data available so far. Measurements included the breakdown-threshold energy

density, the absorption coefficient at the  $\lambda = 10.6 \mu\text{m}$  wavelength, the relative scattering of  $10.6 \mu\text{m}$  and  $0.63 \mu\text{m}$  waves, and the photoluminescence intensity. The specimens were industrial crystals grown to  $90 \times 30 \times 30 \text{ mm}$ , with at least two lateral faces polished, and all measurements were performed on the same specimens. The incident laser pulses had a total duration of  $1.2\text{--}1.5 \mu\text{s}$  with approximately 80 ns above the 50% peak level. Absorption was measured by the method of laser calorimetry, scattering of normally incident waves was measured with an LG-75 laser and an LG-22 laser as sources and correspondingly an FEU-83 photomultiplier and a Ge:Au photoresistor as detectors. Photoluminescence was excited with an LGI-21  $\text{N}_2$ -laser. The results indicate that optical breakdown in these crystals is facilitated by the presence of absorbing inhomogeneities,  $\text{NaCl}$  having the highest thresholds. No correlation has been found between photoluminescence intensity and breakdown threshold or between relative scattering levels and breakdown threshold. The absorption coefficient of  $\text{NaCl}$ , the most resistant crystal, did not exceed  $1.5 \cdot 10^{-3} \text{ cm}^{-1}$ . The results suggest that crystals with an absorption coefficient corresponding to the highest degree of purity should have a low concentration of absorbing inhomogeneities and high thresholds of optical breakdown. Table 1, references 21: 17 Russian, 4 Western.  
[2-2415]

UDC 621:534.647

#### SYSTEM FOR AUTOMATIC RECORDING OF VIBRATION PARAMETERS

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 9, Sep 83 p 25

FEDOROV, B. I., engineer

[Abstract] A system for automatic recording of vibration parameters has been developed in the Soviet Union and is now used in various machine manufacturing plants for vibration and noise monitoring. It consists of 20 accelerometer channels with signal transducers followed by low-pass filters, and one frequency-to-voltage conversion channel. A voltmeter is connected to each channel through a commutator switch and so is a timer which feeds the voltmeter readings to a transcriber for printout and alphanumeric documentation. The printer is also connected to the commutator switch through a device which matches recorded data with the corresponding pickup channel. This SAR-21 system has been designed with maximum use of series produced components. Its measurement ranges are  $0\text{--}600 \text{ m/s}^2$  acceleration and 20-2500 Hz frequency. The recording time is 0.04 s for any one parameter and the error of the system does not exceed  $\pm 2\%$ . Figure 1, table 1.  
[41-2415]

QUANTITATIVE ROUGHNESS ANALYSIS OF TREATED SURFACES WITH HIGHER-CLASS FINISH  
BY METHODS OF X-RAY REFLECTOMETRY

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 6, Jun 83 pp 27-29

SINAYSKIY, V. M.

[Abstract] A method is proposed for roughness evaluation applicable to surfaces with class 13-14 (0.05-0.10  $\mu\text{m}$ ) or better finish, where conventional feeler gauges and optical interferometers become inadequate. The method is based on total reflection of x-rays, using a narrow incident beam of rays at low glancing angles to the treated surface. The integral variant of this method involves measuring the integral intensity  $I_i$  of the reflected signal as function of the incidence angle  $\theta$  and determining the critical angle  $\theta_c$  from the  $R = f(\theta)$  curve ( $R$ - reflection coefficient). The differential variant of this method involves determining the intensity distribution over the profile of the reflected signal, that profile being described by its width  $B$ , the integral intensity  $I_i$ , the peak intensity  $I_m$ , and the intensity as function of double the incidence angle  $I(2\theta)$ . Experimental data necessary for calibration are obtained with a special high-precision x-ray reflectometer. In the integral method it is most expedient to use the critical angle  $\theta_c = f(R_z)$ , in the differential method it is most expedient to use the integral intensity  $I_i = f(R_z)$  and the signal profile width at half-maximum intensity level  $B_{1/2I_m} = f(R_z)$  ( $R_z$ - surface roughness). Universal calibration curves are

obtained by reduction of readings to a dimensionless relative scale so as to cover any material, which makes possible high-precision determination of the critical angle of the signal profile width at very smooth surfaces with near zero roughness corresponding to class 15-16 or better finish. Both methods have been tested on surfaces of steel, glass, and beryllium. Based on attainable accuracy limits of 0.5% and 0.25' in measurement of radiation intensity and critical angles respectively, it is thus feasible to determine the surface roughness within  $\pm 0.01 \mu\text{m}$  by the integral method and within  $\pm (0.015-0.02) \mu\text{m}$  by the differential method. Figures 2, references 3: 2 Russian, 1 Western.  
[39-2415]

DETERMINATION OF PARAMETERS OF ELASTICALLY STRAINED MIRROR FACETS OF RAPIDLY ROTATING PRISMS

Moscow IZMERITEL'NAYA TEKHNIKA in Russian No 9, Sep 83 pp 42-44

TRACHUK, V. S., ROMASHKOV, A. P. and KOTYUK, A. F.

[Abstract] A major problem is design and manufacture of prism-type mirrors for rotation at speeds above 1000 rps is predicting and accounting for elastic

strains, which degrade the performance of such devices in optical systems for measuring the space-time characteristics of optical pulse radiation. This makes it necessary to determine several parameters of the prism mirror facets, foremost among them their radii of curvature and inflection points. Here this problem is treated on the basis of the theory of elasticity, considering that the plane of a rotating prism facet becomes a cylindrical surface with a plane curve as directrix. For simplification, only the normal displacement component is retained and the tangential displacement component is disregarded. The shape of the directrix is determined by the combination of order of axial symmetry of the prism cross section and Poisson ratio of the mirror material. The calculations are demonstrated on prisms with order of axial symmetry (number of mirror facets) not higher than 5, the dependence of the normal displacement on the Poisson ratio being much more intricate in the case of more than five facets and correspondingly higher orders of axial symmetry. This dependence is established parametrically, specific expressions having been obtained for trihedral and tetrahedral prisms most commonly in use. Theoretical computer data have been checked against experimental data on steel and beryllium mirrors rotating at 5000 rps. A plane mirror facet of a material with theoretically zero but practically a very low Poisson ratio, such as beryllium, remains a plane one but shifts parallel to itself during rotation. Figures 2, table 1, references 4: 2 Russian, 2 Western.  
[38-2415]

UDC: 621.824:620.178.3:539.413

#### STUDY OF FATIGUE STRENGTH OF SHAFTS WITH SEGMENTED CHANNELS

Moscow ENERGOMASHINOSTROYENIYE in Russian No 5, May 83 pp 9-11

KUDRYAVTSEV, I. V., doctor of technical sciences, SHOKOV, N. A., engineer, and SAVVINA, N. M., candidate of technical sciences

[Abstract] The influence of segmented channels as structural factors on the fatigue strength of rotor shafts has been little studied. Therefore, an experimental study was undertaken of rotor steel using cylindrical models 70 and 200 mm in diameter with segmented channels. The influence of hardening by surface plastic deformation on fatigue strength of rotor steel was also studied. The tests allowed experimental determination of dangerous points in the cross section—the locations where the segment channels meet the cylindrical surface. Microstructural studies revealed that cementite grains were significantly reduced in size and located in a less ordered manner than in the initial state before fatigue testing. The tests indicated more uniform accumulation of fatigue damage in models worked by surface strain hardening. Surface strain hardening increased the fatigue resistance of 70 mm models from 85 to 155 MPa, of 200 mm diameter models from 45 to 170 MPa. The method of surface plastic deformation is therefore recommended to increase the fatigue strength of large shafts with segmented channels. Figures 3, references 7: 6 Russian, 1 Western.

[15-6508]

INVESTIGATION OF ERRORS OF ACOUSTIC GONIOMETER INFORMATION-MEASUREMENT SYSTEMS  
ON ROCKING BASE

Leningrad IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE  
in Russian Vol 26, No 8, Aug 83 (manuscript received 28 Dec 82) pp 7-11

NAUMENKO, I. Ya., Kiev Polytechnical Institute

[Abstract] The accuracy of azimuth information-measurement systems which determine the direction of arrival of an acoustic wave front is limited severely by the angular errors which occur when the device is operated on an unstable base, such as a rocking ship. This study examines the conversion equation of such a device subjected to rocking-type destabilizing factors and estimates the resulting errors. References 4 Russian.

[6-6508]

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